Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

FEBRUARY, 1957 FIVE DOLLARS A YEAR

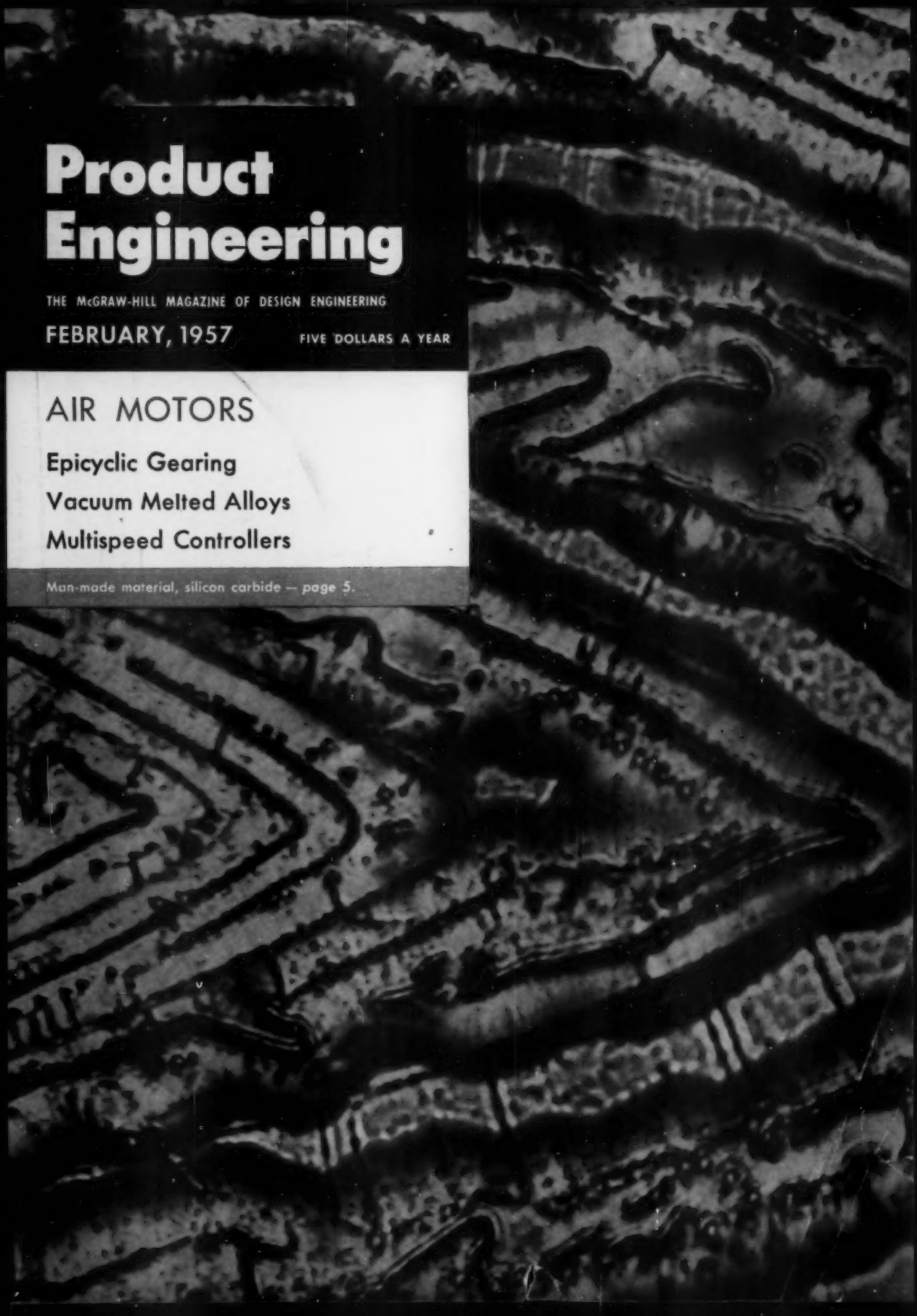
AIR MOTORS

Epicyclic Gearing

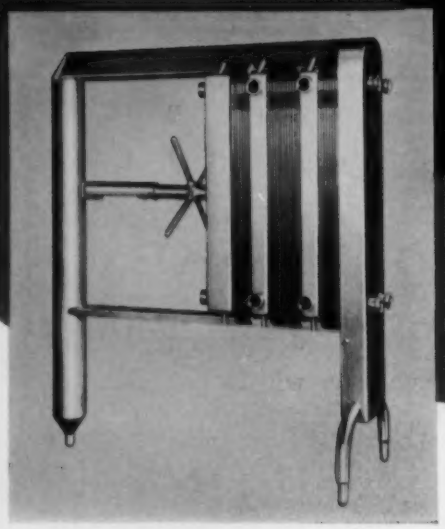
Vacuum Melted Alloys

Multispeed Controllers

Man-made material, silicon carbide — page 5.



Critical purity depends on precision processing



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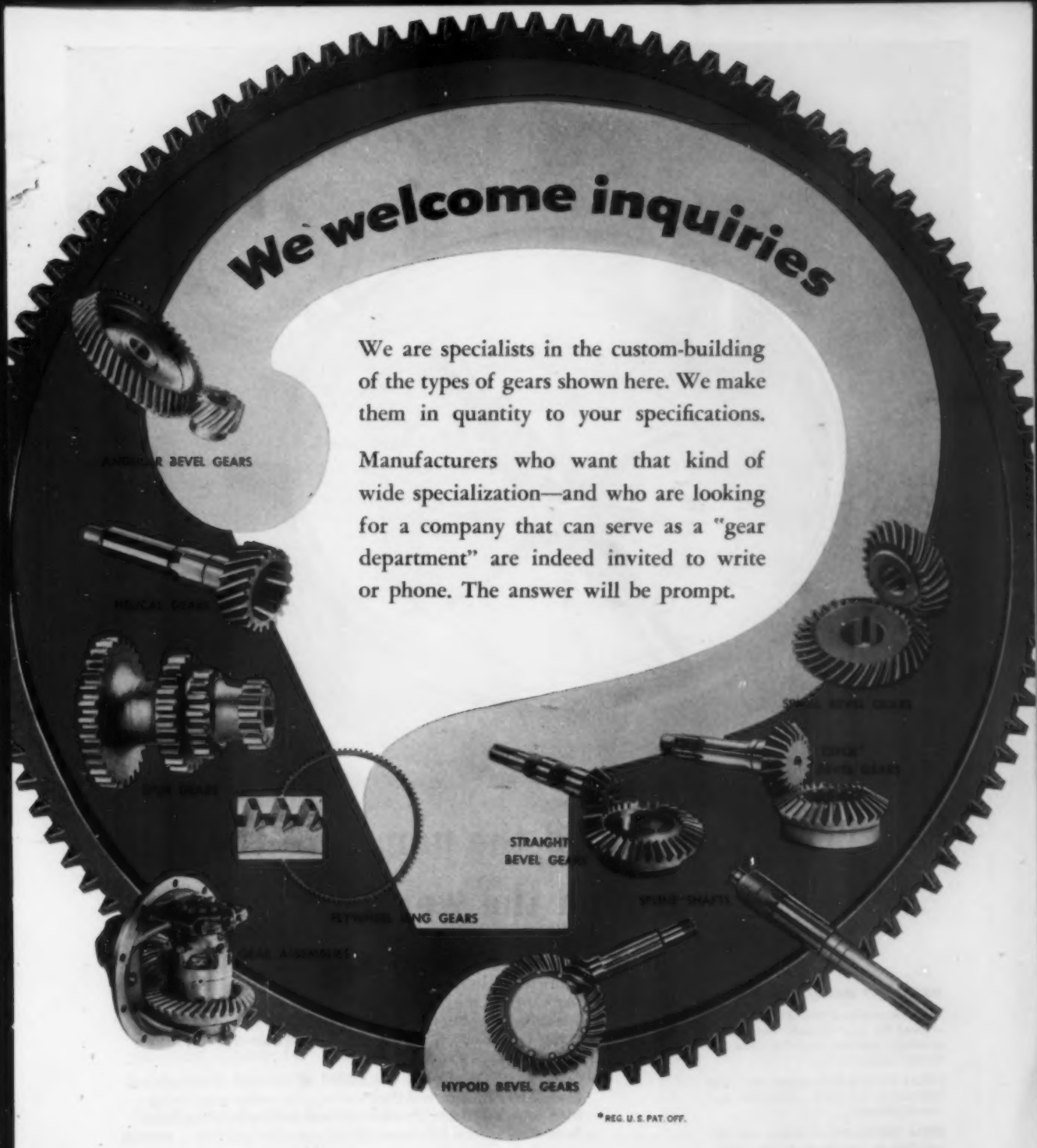

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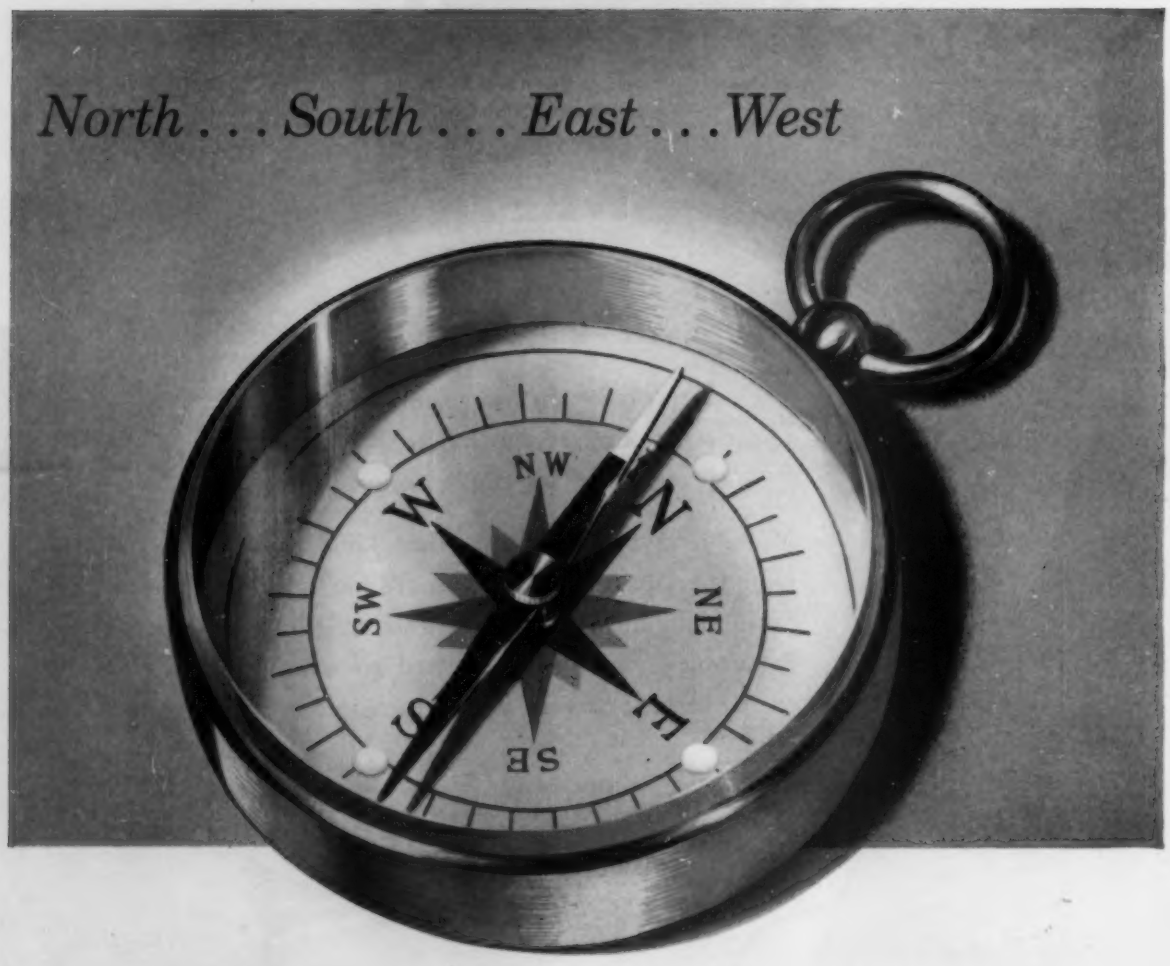

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Product Engineering

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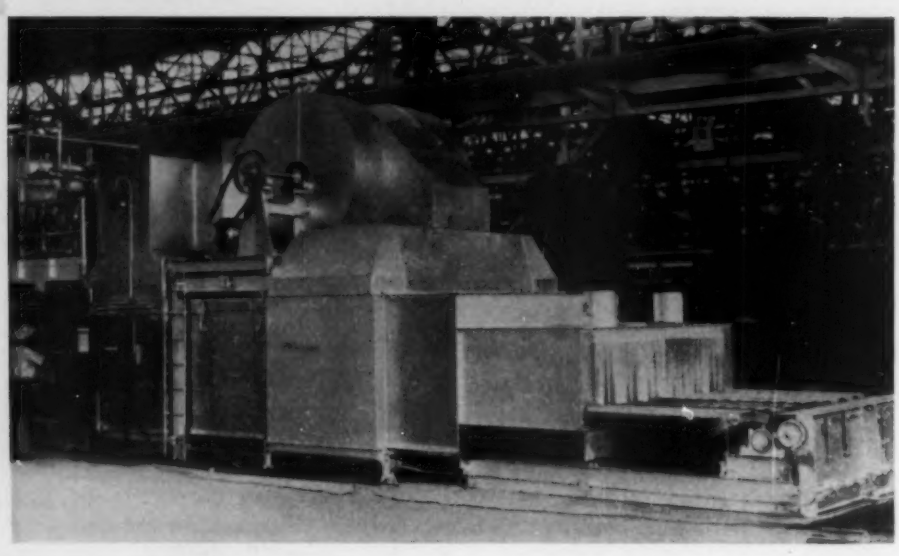

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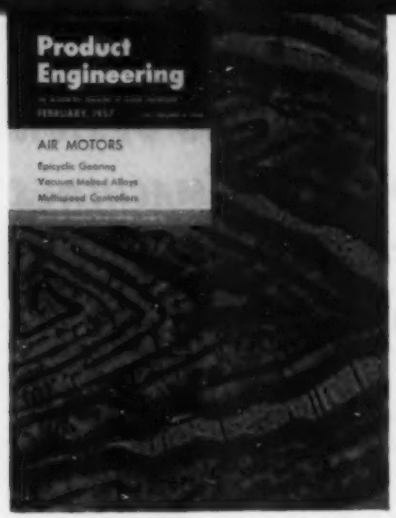

THIS MONTH'S COVER

Silicon carbide structure under polarized light at 1500 magnification; photomicrograph from General Electric Research Laboratory. Crystal growth in the melt starts from a fault or dislocation; growth is in a regular spiral pattern unless deflected by interference with another crystal. Structural parts made of this material have unusual resistance to abrasion and corrosion—see article starting on page 135.

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Interesting to Note . . .

Safe Reins for Iron Horses

THE growth of American railroads has brought forth a legend of heroism, romance and adventure. Early days of railroading were marked with accidents and death that were considered normal occupational hazards to the stalwart men of the great iron road. In 1866 a young Vermonter named George Westinghouse was on a passenger train that was delayed by a collision between two freight trains. He thought that, "if the engineer of these trains had had some means of applying brakes simultaneously to all the wheels of their trains, the accident might have been avoided."

Westinghouse thought of several types of braking devices that could save lives. A brake attached to the coupling mechanisms, or steam pressure to force a brake to engage, were tried unsuccessfully. One morning, he happened to come across a magazine article describing the building of a tunnel in Mont Cenis, Switzerland, by the use of compressed air. This was his answer. By 1868, he had developed the first successful compressed-air brake. He assembled his invention on a locomotive and four cars and invited railroad officials to see his "air brake" in operation. As the test train emerged from a tunnel near Union Station, Pittsburgh, the engineer, Daniel Tate, saw a horse and wagon standing upon the tracks. In panic, the horse threw its driver in the path of the train. Tate twisted the brake valve and halted the train within four feet of the unconscious drayman. This unexpected occurrence dramatically demonstrated the advantages of air brakes. The success of the test enabled 23-year-old George Westinghouse to capitalize the Westinghouse Air Brake Co. at a half million dollars.

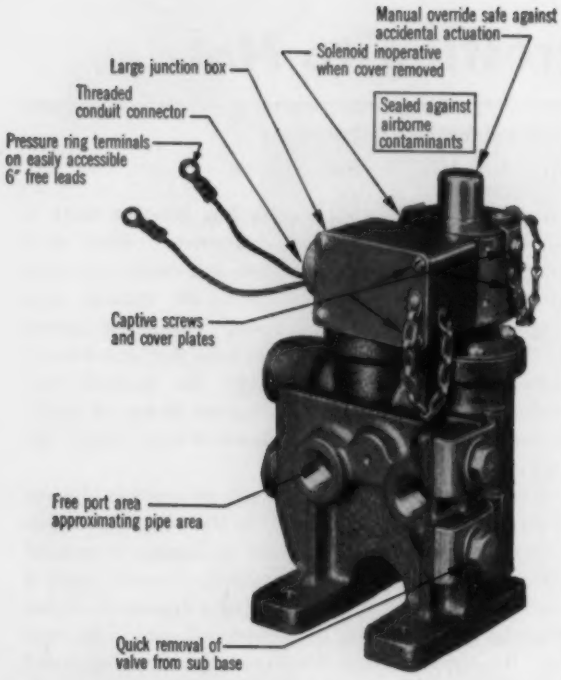
Compressed air, the answer to Westinghouse's search for a safe brake, is also the source of power for millions of pistons—in tools, gages, clamps. One of the newer applications is in the air motor. An article on the Analysis and Design of Air Motors will be found on page 167.

One Live Body Named Reppe

THE extent of German work with chemicals was not fully realized until the conclusion of World War II. At that time it was learned that a great amount of research had been undertaken for the production of synthetic rubber from acetylene and carbon monoxide. It was further learned that the foremost German expert in this field was Dr. Julius W. Reppe, a prisoner in a British detention camp.

At the request of the American Chemical Society in 1945, the Chemical Corps tried to pursuade Dr. Reppe to write a full exposition of his work on acetylene chemistry. Reluctantly, Dr. Reppe agreed to do the work provided he was released and allowed access to his numerous files. British authorities released their prisoner, obtaining a signed formal

(Continued on page 7)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Pointed out on the photo above are the JIC features which are a must for many equipment manufacturers to gain acceptance of their machines in a growing number of production conscious plants. However, they offer obvious advantages even where they are not specifically demanded. Furthermore the JIC type Crescent solenoid is completely interchangeable with standard solenoids for the convenience of those manufacturers who want the JIC features available only for required application.

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It operates freely on dry, unlubricated air, and dirt or pipe scale in the line cannot damage the valve or hold it open because of the unique "Shear-Seal" design.

The leak-proof holding quality which does not diminish after prolonged service is perhaps the most outstanding characteristic of the wear-compensating "Shear-Seal."

The external design stresses savings through convenience of porting, any port can be the "in" port; of mounting, valve has a bracket that may be shifted or removed to make way for panel mounting; of maintenance, valve can be serviced without touching the plumbing.

Ask for bulletin A-5.

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receipt for "one live body named Reppe."

Food and lodging were hard to acquire for Dr. Reppe. U. S. Army rations could not be fed to Germans. The city of Frankfurt wouldn't feed or house him because he was not a resident. Since he had joined the Nazi party, military regulations required him to work on a road gang. To avoid this, he was held as a detainee, which caused him more chagrin.

Since Reppe had previously worked with a large number of experts in a supervisory capacity, he had only a broad knowledge of his subject. He therefore required the aid of two of his former co-workers and access to his files. His assistants, Drs. Hans Trieschmann and Otto Hecht, were living in the French Zone and were not too difficult to acquire. The documents were another story, for they were scattered throughout Germany. At long last, Reppe was given his assistants and some twenty-eight tons of documents; a large portion of which were found to be worthless. Dr. Reppe became less cooperative and at one point attempted to escape from his laboratory in Gensdorf to a town 230 miles away. His escape might have been successful had he not tried to secretly transport his tons of documents with him.

Reppe was finally released from his task and his entire files were turned over to allied authorities. Using the notes of Dr. Reppe, a manuscript was eventually prepared and published by J. Copenhaver and M. H. Bigelow on the chemistry of acetylene and calcium carbide.

The carbides have had tremendous effects on modern industry—not only of acetylene, but also of tungsten, boron, vanadium—and one so common we frequently forget it. That's silicon carbide, the workhorse abrasive, pictured on our cover and the subject of an article beginning on page 135.

The Gear and the Pendulum

THERE is a story told of a doctor who was introduced to a woman at a cocktail party as Dr. Black—a naval surgeon. The woman thereupon replied, "My, but you doctors do specialize these days." Although the veracity of this story may be questioned, it is true that specialization is far more prevalent today than it was in yesteryear, and in the U. S. than in Europe.

In the seventeenth century for example there lived a Dutchman, Christian Huyghens, who personally contributed to a multitude of sciences. As a mathematician, he published an essay criticizing Gregory of St. Vincent's method of quadratures. As an astronomer, he discovered a satellite to the planet Saturn; as an optical designer, he developed a new method of grinding and polishing lenses. In this field he devised an "aerial telescope" by mounting several lenses of enormous focal length on poles connected to the eyepiece by means of a cord.

One of his most important contributions was as a physicist. Huyghens contemplated involute and cycloid curves for obtaining uniform impact with large pendulums. He determined a relationship between the length of a pendulum and the time of its oscillation. This led to his theory of evolutes and the discovery that the cycloid is its own evolute and is tautochronous. His theories on centrifugal force in circular motion aided Newton in formulating his law of gravitation. The work of this curious bachelor has had a tremendous effect on gear design.

An article discussing some novel applications of epicyclic gearing begins on page 194.

In This Corner — Ford!

THE files of the American Patent Office are filled with contraptions and devices that would amaze a modern Jules Verne. From the first patent in 1696 issued to Joseph Jenkes for the "manifacture of engines of mils to go by water" (sic) to today's atomic engines for travel in outerspace, the story of patents is indeed an interesting one.

In 1879 for example a patent was filed for an ingenious "road engine" that affected the history of the automobile industry for years to come. George S. Selden, a patent lawyer with an interest in engineering, built a three-cylinder internal combustion engine which used a liquid hydrocarbon distilled from crude petroleum as fuel. Selden was paid $10,000 plus royalties for this invention by the Electric Vehicle Co. and the Association of Licensed Automobile Manufacturers in order that a trust could monopolize the production and sale of cars. All those who joined the ALAM reserved a license to sell cars in return for a percentage of "patent royalties." A small auto producer, the Ford Motor Car Co., refused to accept the validity of Selden's patent and produced cars without paying royalties to the Association. Suit was brought against Ford by the ALAM and the Electric Vehicle Co. who had an aggregate strength of seventy million dollars against some twenty-eight thousand dollars held by Ford. The validity of the Selden patent meant not only life or death for the Ford Motor Car Co. but also the possibility of criminal proceedings against all those who owned Ford cars. The fight between the "tyrannical trust" and the "struggling little" company was dragged through the courts for eight years before the Circuit Court of Appeals decided in favor of Ford.

The Court's decision saved the Ford Motor Co. and again showed how our patent laws are designed not just as an inventor's safeguard but also as an industrial safeguard.

The story of the invention and successful patenting of an automatic bowling-pin setter begins on page 140.

Proved in Service... Meet MIL Specifications

Mallory Vitreous Enamel Resistors

Mallory wire wound, vitreous enameled resistors (power type) have been proved in long service to industry. They have recently been certified as meeting MIL specifications under classifications G and V, MIL-R-26C, in the range of sizes and power ratings shown below.

"Thermally balanced" construction, pioneered by Mallory, assures excellent resistance to thermal shock, in addition to other severe environmental hazards. The leads are spot welded to rugged tab-type terminals. Mounting feet are supplied with all values having 50-, 100- and 200-watt power ratings, and are available for 5- and 10-watt sizes.

Other members of the Mallory line of accepted and proven power resistors for commercial service include Cement-coated, Axial-lead, Vitreous enamel coated adjustable, and type K variable resistors. Whether your requirements are for commercial or military equipment, you can rely on Mallory for dependable components.

MALLORY MIL Types

RW-29	0.10— 5,600 ohms
RW-30	0.10— 2,500 ohms
RW-31	0.10— 6,300 ohms
RW-32	0.10— 10,000 ohms
RW-33	0.10— 18,000 ohms
RW-35	0.10— 40,000 ohms
RW-36	0.10— 56,000 ohms
RW-37	0.10— 90,000 ohms
RW-38	0.10—140,000 ohms
RW-47	0.10—180,000 ohms

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Parts distributors in all major cities stock Mallory standard components for your convenience.

Developments

To Watch

CLADDING SHEET STEEL WITH TITANIUM . . . .

. . . . by a new British process has recently been announced by the Lukens Steel Co. there. The successful operation of the process depends on the initial electroplating with iron or nickel of one side of the titanium sheet which is to be used for cladding. During this electroplating process the other side of the titanium sheet is protected by a lacquer coating. The lacquer is then stripped off the titanium and the plated side of the sheet is placed in contact with the steel plate and enclosed inside a gas-tight graphite coated steel cover into which inert gas is led by a series of special pipes. When all the air has been removed, this pack containing the plated titanium and the sheet of steel to which it is bonded, is heated to 1000-1500 F for a period of time which varies according to the thickness of the sandwich formed by the titanium sheet and steel sheet. After heating, the pack is compressed to a thickness of not less than 20 per cent by rolling, pressing or forging.

A SERIES LIGHTWEIGHT RIFLES . . . .

. . . . both for the military and sporting use is in the offing. The Fairchild Airplane and Engine Corp., Hagerstown, Md., is continuing the development of the Armalite weapons originally developed by one George Sullivan. Now being tested by the Army is the AR-10, 0.308 caliber infantry model. The rifle uses a 20 round pre-loaded non-ferrous alloy magazine which weighs less than 4 oz. Steel magazines weigh twice as much. Extensive use of plastic foamed parts and aluminum reduces the over-all gun weight to 6.85 lb, which is almost three pounds lighter than the Garand semi-automatic rifle. It weighs about the same as the World War II carbine. To reduce weight, an aluminum barrel with a swaged-in stainless steel inner barrel is used, plus aluminum and stainless steel actions, and Fiberglas and plastic foam stocks.

TAPE-ON SURFACE TEMPERATURE RESISTORS . . . .

. . . . for temperature telemetering can be applied to any surface quickly, without any holes being drilled. Developed by Trans-Sonics, Inc., Box 328, Lexington 73, Mass., the sensing element is applied to the surface by a piece of mylar tape. With an output of up to 5 v without amplification, the resistors can be used directly in a commutation circuit to modulate standard telemetering transmitters. The resistors are available in various ranges from —300 to 400 F, and are furnished with two 6 in. long glass fiber covered constantan leads. The resistance change over the specified range for the new type 1371 resistor is 100 ohms.

DIGITAL OUTPUT-INPUT TRANSLATOR SYSTEM . . . .

. . . . in a new analog computer series designed for automatic operation and high accuracy. By using a typewriter and punched tape system to set up and check problems, the new EASE 1100 series are reported to save hours of computing, and make practical an installation of any size. The electric typewriter system permits

(*Continued on page 10*)

complete computer control, including pot set and electronic function set-up. Solutions can be run and re-run automatically. As a point-by-point check, the typewriter first prints the desired address and value. After the servo-set system nulls, the actual address and value set is printed. Other features include pushbutton monitoring, automatic problem checking, redesigned servo-set potentiometer system, and a stable temperature-controlled oven. Designed by Berkeley Div., Beckman Instruments, Inc., 2200 Wright Ave., Richmond 3, Calif., all computing resistors and capacitors are adjusted to better than 0.005 per cent.

AN ATOMIC ENERGY POWERED LOCOMOTIVE . . . .

. . . . is in the planning stage by the German Federal Railways, and will be smaller and lighter than that presently being considered in this country. U. S. plans indicate a 14 axle locomotive of 6900 hp with a total weight of 330 tons. The German engine will have only 8 axles, an output of 5916 hp, and a total weight of 175 tons. It will be powered by a gas-cooled reactor, and will have no refrigerator car nor secondary safety devices. The locomotive is expected to cost $476,000 and running costs are expected to be $0.48 per kilometer if it travels 200,000 kilometers annually. This would be less than the operating cost of a steam engine, but slightly higher than that of a diesel-electrical engine.

SMALL AND UNUSUALLY STABLE ELECTRICAL RESISTORS . . . .

. . . . made of nitrided films of chromium and titanium can be operated at full load at temperatures of about 300 F. Besides good electrical stability under a wide range of operating conditions, the resistors have good moisture resistance. According to tests at the Battelle Memorial Institute, London, England, the resistor units can be made with exactly reproducible properties. Unsealed film resistors made of this material will operate for 1000 hr at 300 F with a change of only a few per cent in their electrical resistance.

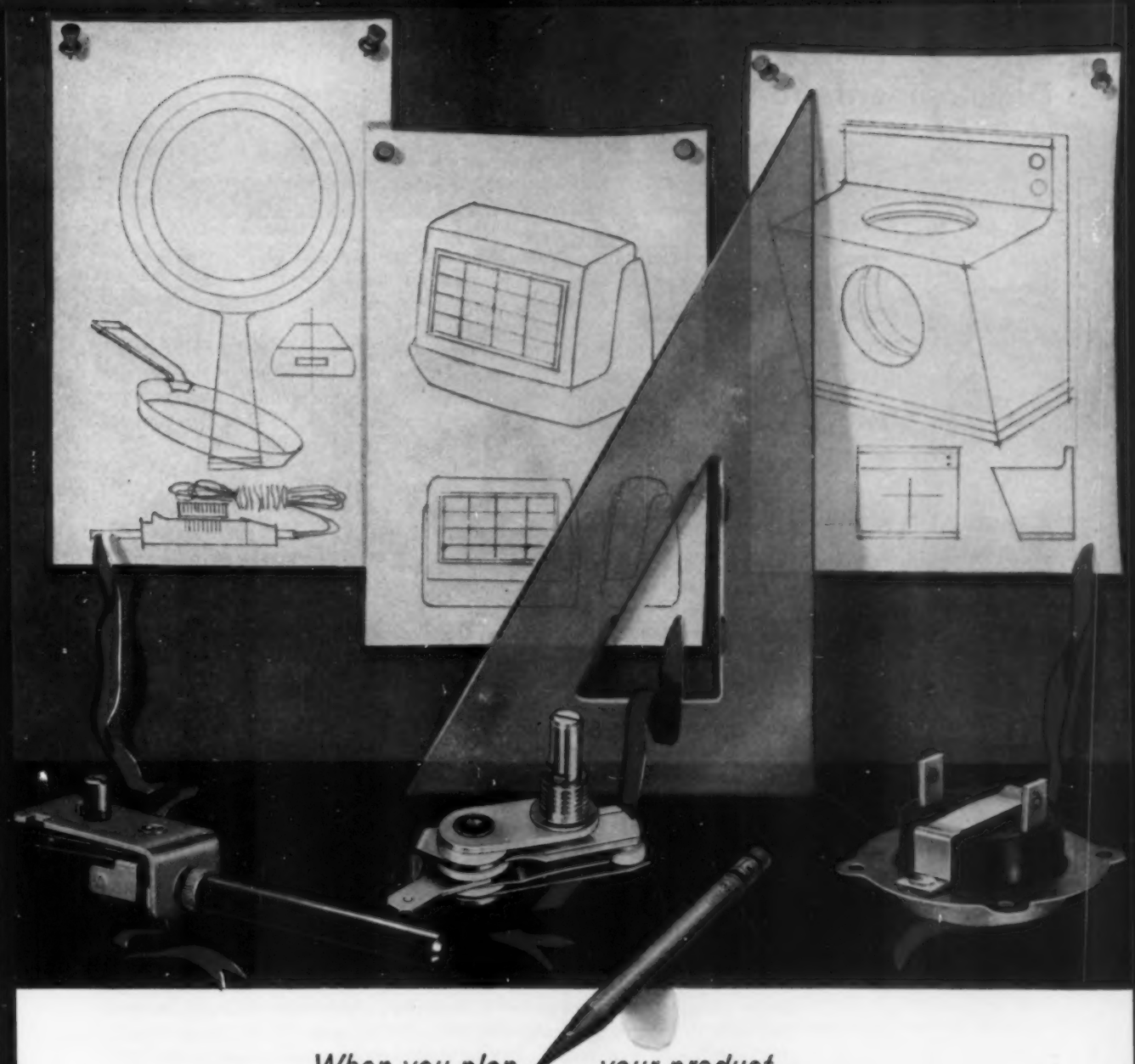
DETECTING POROSITY IN PLATED COATINGS . . . .

. . . . is possible with a nondestructive method just announced by the National Bureau of Standards, Washington 25, D. C. The new method involves photographing an electroplated specimen exposed to radiation, and will determine both the size and position of the pores. A flat sheet of plated metal several thousandths of an inch thick is placed on a photographic film with the coating against the film emulsion. The basis metal side of the specimen is exposed to X-rays or radiation from a radioactive material. To get good contact, the X-radiation used must be soft. This limits the thickness of the basis material to several thousandths of an inch, since a thicker metal absorbs too much of an X-ray beam and requires too long an exposure time. On the developed film, a black spot appears wherever a pore existed in the coating. This method detects pits, voids, and inclusions of about 0.001 in. in dia.

CERAMIC COATINGS REDUCE CREEP RATE OF ALLOYS . . . .

. . . . under stress at high temperatures. In a recent study at The National Bureau of Standards, Washington 25, D. C., results indicate that under some conditions a coating can reduce the creep rate by as much as 50 per cent, while under other conditions a harmful effect is observed. The alloys studied were representative

(*Continued on page 12*)



When you plan your product

look to STEMCO THERMOSTATS *first*

TYPE H†—Positive acting, adjustable, for fry pans, skillets, and other appliances. Fail-safe, open in low to 500°F in high. Rated at 1650 watts at 115 volts AC. Request Bulletin 10,000.

TYPE S*—Adjustable (nozzle mounting shown) and non-adjustable styles. Positive-acting. Operation to 600°F. Rated at 15 amps at 115 volts AC; 7 amps at 230 volts AC. Screw and spade terminals. See Bulletin 1000.

TYPE D*—For laundry dryers or other surface and warm air applications. Snap-acting disc type UL approved for operation to 300°F. Rated at 25 amps at 120-240 volts AC. Open or enclosed styles. Bulletin 8000.

With competitive conditions ahead, you're probably reappraising your product line. Or completely redesigning. Either way, that's the time to look into the Stemco thermostat line. ¶ Strip or disc types . . . positive or snap acting . . . adjustable or non-adjustable . . . virtually any type of terminal arrangement or mounting provision. We have no prejudices, play no favorites—*we make them all.* ¶ No other line of bimetal thermostats has as many styles in production. This, combined with Stevens application engineering service, means you profit from important savings in being able to use production line Stemco thermostats for your special needs. Try us *now.*

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**Refer to Guide 400 EO for UL and CSA approved ratings.*
† Patent Applied For

STEMCO THERMOSTATS

STEVENS manufacturing company, inc.
Lexington and Mansfield, Ohio

of materials having good high-temperature oxidation resistance, and included two 80 Ni-20 Cr alloys. Both of the alloys differed significantly in manganese, iron and silicone content, and both coated and uncoated samples were tested. Of the various combinations of stress and temperature imposed, those at 1975 F and 600 and 1200 psi showed the greatest reduction in creep rates of the ceramic coated specimens, compared with the uncoated specimens. Analysis showed that the uncoated specimens lost twice as much chromium as the coated specimens tested at the same temperature.

At 1800 F and 2200 psi the initial creep rate of the ceramic coated (NBS coating N-143 containing cerium oxide) specimen was well below that of the uncoated specimens. But after about 20-30 hr, the creep rate of the ceramic coated specimens rapidly increased, showing an even greater rate of increase than the uncoated. Fracture of the coated specimens usually occurred during this period.

A VACUUM TUBE WITH BUILT-IN MEMORY . . . .

. . . . is a storage cathode-ray tube in which the display of an oscilloscope can be written, stored and viewed continuously. Called the Iatron storage tube, continuous viewing of the display which will be stored for several hours is provided by a divergent electron beam, called the flooding beam, which expands until its spot covers the display area of the tube. Besides reducing the expense of photographing oscilloscope displays at low frequencies, a visible trace may be stored at writing-spot velocities up to almost 1-million centimeters per second. Any trace can be stored for examination or it can be erased immediately. The new tube was developed by The Farnsworth Electronics Co., Div. of International Telephone & Telegraph Corp., Fort Wayne, Ind.

AN IMPROVED HIGH PRESSURE PACKING MATERIAL . . . .

. . . . made of Teflon impregnated with 5 per cent by weight of molybdenum disulphide has been used effectively at pressures of about 200,000 psi in tests at the National Bureau of Standards, Washington 25, D. C. It was used as packing in the high pressure moving seal of differential area pressure intensifiers. These intensifiers were found to have from 10 to 15 per cent less over-all friction than similar pressure intensifiers packed with leather. After more than 100 hr. under load with 18 pressure applications between 100,000 and 190,000 psi, no signs of packing extrusion were found. Further studies on impregnated plastics are underway as are studies on the effects of changing the size angles and materials used in extrusion rings.

AND IN ADDITION . . . .

. . . . Last month the University of Colorado started teaching courses in a new department of astro-geophysics, reputed to be the first of its kind in U. S. colleges; as opposed to astronomy which is the study of celestial bodies, astro-geophysics deals with the relationship between astronomic bodies and the earth . . . . E. I. du Pont de Nemours and Co. announced a fund of more than $1-million for grants to 122 universities and colleges for the next academic year; more than half of the program is for the improvement of teaching . . . . General Electric announced a new line of germanium rectifiers for use in mass-produced television sets; prices are competitive with other types of TV dry rectifiers . . . . Plastics production passed the 4-billion pound mark in 1956 by increasing 10 per cent over the 1955 figure, which was 30 per cent over 1954; polyesters and polyethylene were up 30 per cent; total plastic production in 1957 is estimated to be up 5 per cent . . . .

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NEW fatigue-proof STEEL BAR

..the bar that has HIGH STRENGTH without heat treating

Yes, La Salle invites you to test a sample bar of the remarkable new FATIGUE-PROOF. This amazing new material is its own best recommendation . . . as proven by the many original equipment manufacturers who have already tested (and are using) FATIGUE-PROOF.

If you are making parts requiring strengths in the tensile range of 140,000 to 150,000 psi, and want to eliminate the expense or problems of heat treating . . . if you want to save production costs with a bar that machines faster (25% faster than annealed alloys—50% to 100% faster than heat treated alloys) and gives you a beautiful finish, too . . . if you want to improve the quality of your product while saving money, send us a blueprint, drop us a note giving application details, or better yet . . . pick up your telephone and call a La Salle sales engineer (REgent 4-7800, Chicago, Illinois).

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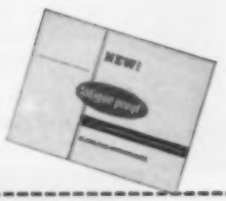

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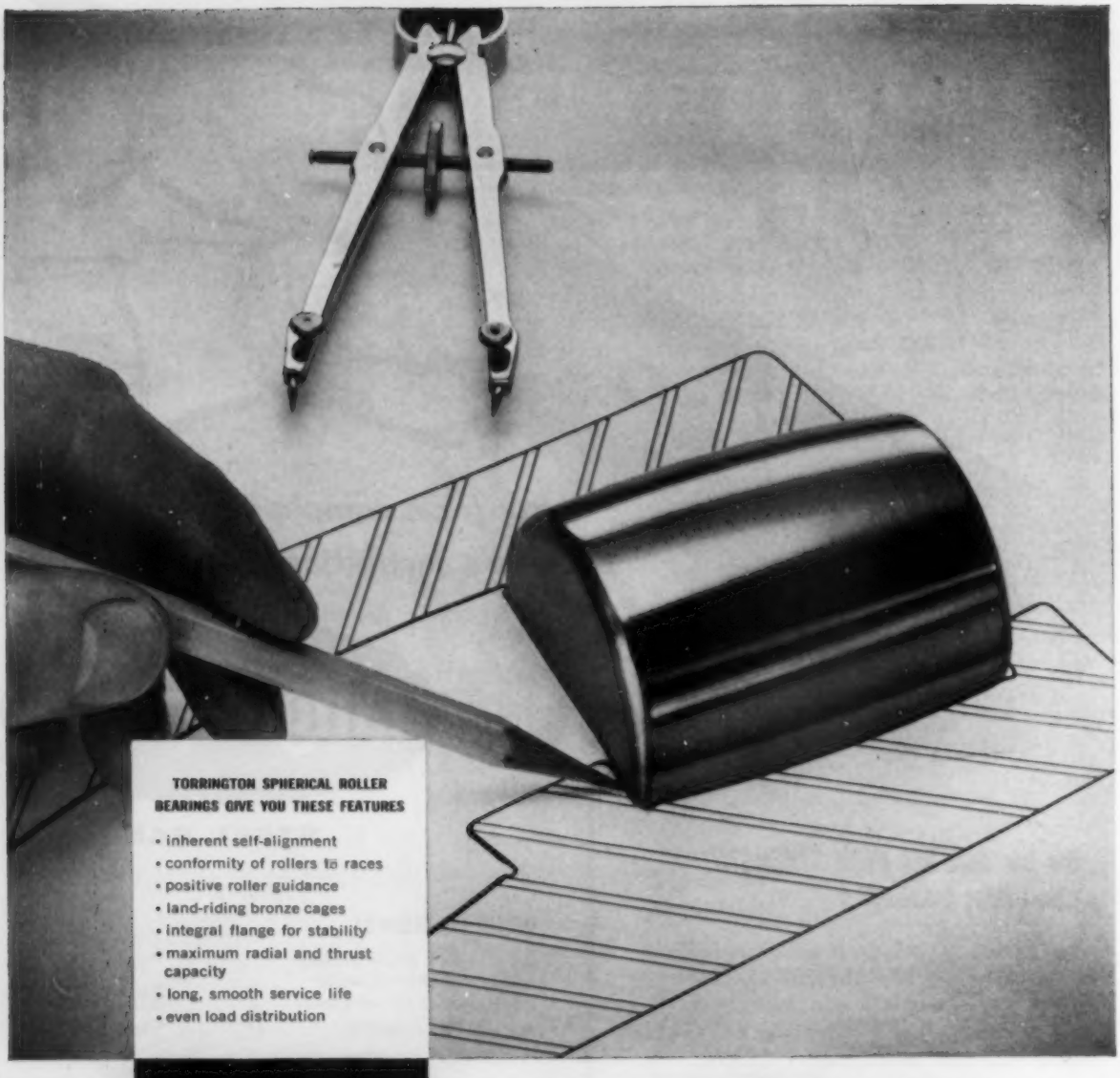
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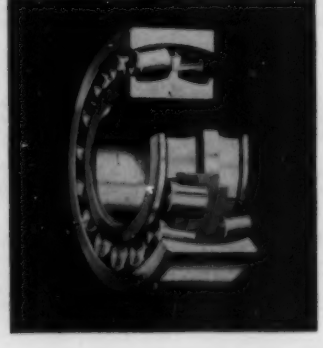

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This is the kind of feature Torrington builds into its bearings out of its experience with all major types serving in all kinds of equipment. Care for such details is matched only by our care in mating the *right* bearing to the *right* job. In this, your Torrington representative is an expert: call on him when you need help. *The Torrington Company*, South Bend 21, Ind.—Torrington, Conn.

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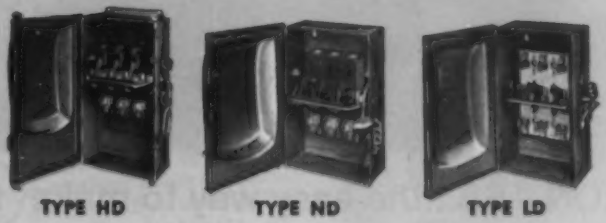
• The table below shows Square D switches meeting new industry specifications. Notice how they clarify conflicting features which existed under old designations. Notice, too, that they establish a new, heavy-duty industrial switch, Type HD.

One important thing which remains unchanged is the **DESIGN LEADERSHIP** which has made **SQUARE D SAFETY SWITCHES** industry's overwhelming **FIRST** choice for more than fifty years. Compare them, feature for feature. They cost no more, why settle for less?



TYPE HD TYPE ND TYPE LD

DESCRIPTION	HEAVY DUTY New	NORMAL DUTY formerly Types H, S, or A	LIGHT DUTY formerly Types D or G
Rating-Ampere Voltage	30—600 250 or 600V AC, DC	30—1200 250 or 600V AC, DC	30—200 250V AC
Enclosure	NEMA 12 • Industrial Use (Gasketed) NEMA 4 & 5 • Water-tight & Dust-tight NEMA 7 • Explosion-resisting Class I—Group D NEMA 9 • Explosion-resisting	NEMA 1 • General Purpose NEMA 3R • Raintight	NEMA 1 • General Purpose NEMA 3R • Raintight
Horsepower Rating	NEC Fuse Ratings Dual-Element Fuse Ratings	NEC Fuse Rating Dual-Element Fuse Ratings	NEC Fuse Rating
Operating Mechanism	Quick-Make, Quick-Break Independent of Handle	Quick-Make, Quick-Break Independent of Handle	Positive Make, Positive Break Spring Assisted
Cover	Interlocked & Padlock Attachment	Interlocked & Padlock Attachment	Padlock Attachment
Plating—Current Parts	Extra-Heavy Silver	Silver	
Endurance	Maximum Endurance Far Exceeds UL Standards	Exceeds UL Standards	Meets UL Standards

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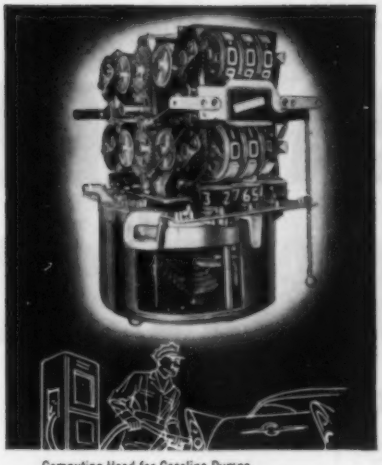
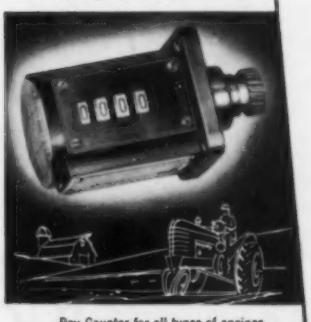


Computing Head for Gasoline Pumps

"Master Meter Duplicator" prints receipts for fuel oil delivered from trucks

"Vary-Tally" Multi-Unit Reset Manual Counter



Rev-Counter for all types of engines

Everyone Can Count on VEEDER-ROOT

Everywhere you look in everyday life, you see a familiar face . . . the face of a Veeder-Root Counter or Computer. From gasoline pumps to fuel oil trucks to textile mills . . . in the home, on the farm, in business and commerce, in modern automated industry . . . Veeder-Root standard and special devices are keeping everything under *Count*rol . . . manually, mechanically, electrically. And the mathematical probabilities are mighty high that *you* can count on Veeder-Root, too . . . to your advantage and profit. Why not let us figure out how, *right now*?

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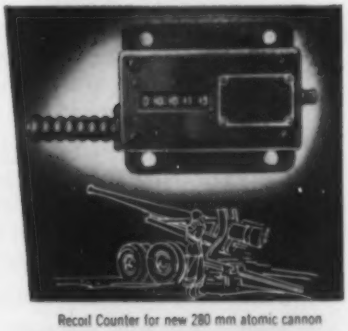
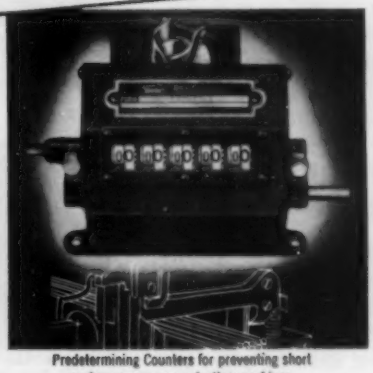


Recoil Counter for new 280 mm atomic cannon

2-3-4 Convertible Counters (and others) for textile machinery

Fuel-Remaining Counter for aircraft . . . subtracts as fuel is used

Small Square-Case Counters for office and other machines



Predetermining Counters for preventing short and over-runs on production machines

Range Timer . . . easy to read . . . easy to set

STOCKS OF STANDARD COUNTERS AVAILABLE AT — Greenville, S. C. • Chicago 6, Ill. • New York 19, N. Y. • Los Angeles • San Francisco
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"I proved it to myself... and you can, too...

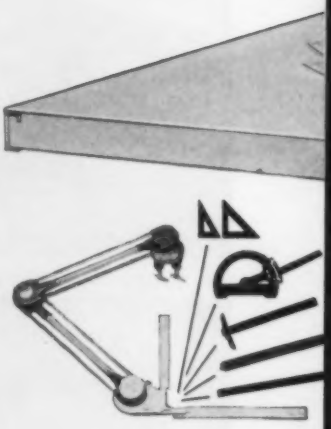
"BRUNING DRAFTERS DRAFTING JOBS BY 20

BRUNING DRAFTERS ADD MANPOWER TO THE DRAFTING ROOM — NOW WHEN YOU NEED IT MOST!

DRAFTSMEN! Prove it to yourself as have hundreds of skeptics who once frowned on using anything but conventional drafting tools like the T-square, triangle, and protractor. Bruning drafters actually speed drafting up to 40% on most jobs, up to 50% on some structural drawings . . . make your work far easier.

DEPARTMENT HEADS! The boom in production means pressure for more and more engineering drawings. With drafting space at a premium and experienced draftsmen hard to get, you couldn't find a faster or better way to add "manpower" than by boosting the output of your present draftsmen with modern, efficient Bruning drafters.

BRUNING DRAFTERS SPEED DRAFTING because they combine T-square, straightedge, triangle, protractor, and scales in *one* precision instrument. You eliminate the time and effort previously diverted to lifting, sliding, replacing, and reaching for these separate tools. Easily and quickly, you rotate, turn, and lift your Bruning drafter—all with the left hand. With fast fingertip control, you set and lock scales to any base line or angle. You accomplish everything that you can do with the conventional five basic instruments—only you do it much faster and much more accurately!



WHY BRUNING DRAFTERS ARE EASY TO OPERATE!

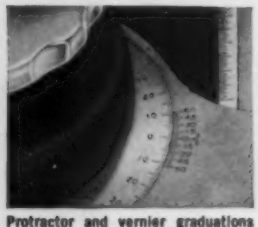
Bruning design permits complete 360 degree rotation about both the head and mast, making all parts of the board easily accessible—scales remain parallel to original angle setting. Patented Equipoise mechanism counteracts gravity on slopes up to 15°, literally "floats" your drafter into place without sag or "kickback." Exclusive Scalock device makes it easy to change scales, holds scales rigid while in use.

Automatic indexing stops at 15° intervals are engaged and released by just a press of the button on Bruning's unique Touch Control.

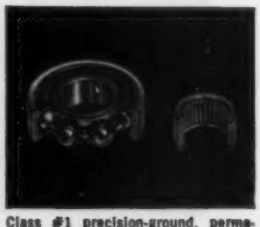
A ball-type joint between arms lets you lift your drafter over objects without unbalancing the machine or disturbing alignment of scales.

WHY BRUNING DRAFTERS ARE TOPS IN PRECISION AND DURABILITY!

Protractors have engine-divided graduations and double verniers reading to an accuracy of 5 minutes on most Standard models, to one minute on Civil Engineer models. A mathematically precise system of pulleys, machined to a tolerance of 0.0002", assures that drawing edges remain absolutely parallel to their original angle setting. Sturdy construction of the finest materials insures lasting accuracy and trouble-free operation.



Protractor and vernier graduations are set flush in the same plane to eliminate parallax error. Easy-to-read graduations are engine divided for accuracy.



Class #1 precision-ground, permanently lubricated ball bearings and frictionless needle bearings assure accuracy, effortless operation, and long life.

SPEED TO 40%!"

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Exclusive Equipoise gravity compensator—finest on the market—permits use of drafter on inclined boards.

Standard protractor models—for mechanical, architectural, and structural draftsmen—are equipped with automatic indexing stops at 15° intervals. Civil Engineer protractor models—for civil, municipal, and utility engineers—have an azimuth scale, magnifier, and micrometer adjusting wheel. Arm lengths available to cover board areas from 36"x60" to 48"x96". Wide variety of scales. No extra charge for left handed models.

BRUNING TRACK DRAFTERS bring new space-saving efficiency and accuracy to firms that need extra-large drawings. Both single-arm and double-arm models offer automatic indexing, double verniers, and fast scale changes. Models are available to provide vertical coverage up to 84", unlimited horizontal coverage.

BRUNING COUNTERBALANCED DRAFTERS provide unusual speed, and accuracy in vertical drafting. Available with Standard or Civil Engineer head and same arm lengths as Equipoise drafters.

BRUNING DETAIL DRAFTERS are a lighter, more compact, and less expensive variation of larger Bruning machines. Ideal for smaller drawings and use in shops, schools, and in the field.

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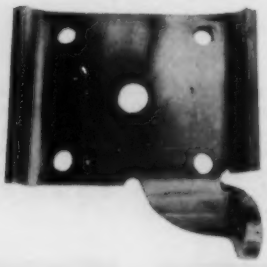
Why this particular rear spring bracket becomes important to all manufacturers

In itself, the ArmaSteel spring bracket described here is of small interest except to the automobile manufacturer for whom we made this study. But this bracket becomes significant as a typical example of what is being done—what can be done—here at Central Foundry Division to increase strength, reduce weight, and reduce the cost of many types of parts by means of relatively new stress analysis testing techniques.

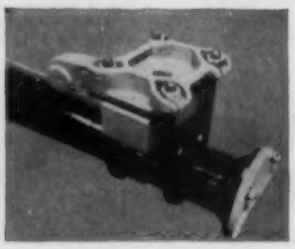


1

The steel stamping for the rear spring bracket (clip pad) of a popular passenger car. ● Made from .438 stock, S.A.E. #1015 steel, the part weighs 4.2 pounds. From this, a casting is to be evolved with these specifications: 800 pounds maximum push or pull load on shock absorber ear, 75 foot-pounds assembly torque load on each U-bolt lock nut.

2

Cast design no. 1 is created. ● Already slightly lighter in weight (4 pounds) than its stamped counterpart, this version is submitted for stress analysis. Preliminary tests indicate this casting is overdesigned. The unnecessary ribs can be eliminated, shock absorber ear can be tapered, and a second, lighter design is evolved, weighing only 3.25 pounds.



3

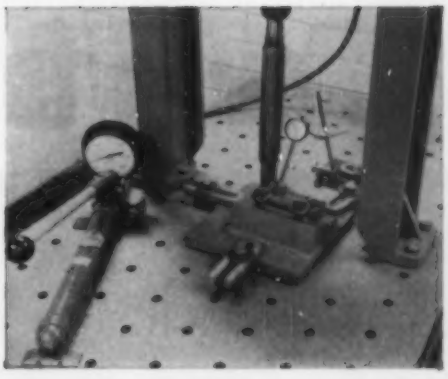
Testing. ● Using a production axle, each casting design is fastened on over rubber pads. The insertion of a steel block duplicates spring thickness. Production U-bolts and lock nuts are also used to duplicate actual loading conditions and torque characteristics.

4

The stress pattern on casting is established. ● Using brittle lacquer, the areas of highest stress concentration are determined so that casting weight can be further reduced without reducing the strength of the part.

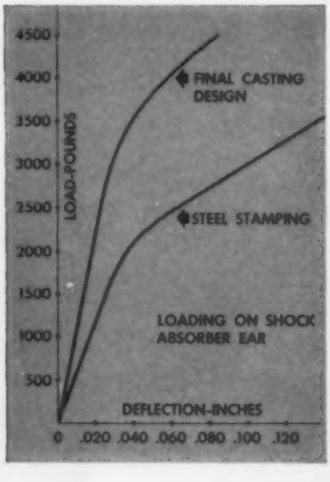
5

The 4th and final design. ● Now weighing but 2.90 pounds, the fourth version is fastened to the test device's loading fixture (shown at right) to test the shock absorber ear for deflection and yield points. This revised version proves the value of stress analysis by sustaining nearly 3,000 pounds load (yield point) at less than 0.30 inches deflection—almost 2,200 pounds ABOVE the auto manufacturer's specifications! *Only now* will the tested design be submitted for approval.



6

Testing shock absorber ear on casting for Deflection and Yield Point. ● The casting was fastened to the loading fixture simulating actual loading conditions using rubber pad and steel block, and load increments were applied on the shock absorber ear.



7

Stress analysis helped create a stronger casting design. ● Above graph illustrates the improved strength and rigidity of the casting over the stamping.

8

Even the actual load on U-bolts was determined. ● Strain gauges, as shown above, were fastened to U-bolts, and strain readings were made at required torque. The bracket, as it finally evolved, assured the auto manufacturer that the final design was without inherent weakness.

Just as we helped this manufacturer to produce a better bracket at lower cost so, too, can our research department assist you by means of the latest equipment and processes including stress-analysis, Cobalt 60, Radiography, Spectrochemical analysis and Sonic testing. Brief descriptions of these and many other phases of modern casting methods are contained in the new book, "SHELL CASTING AT CENTRAL FOUNDRY".

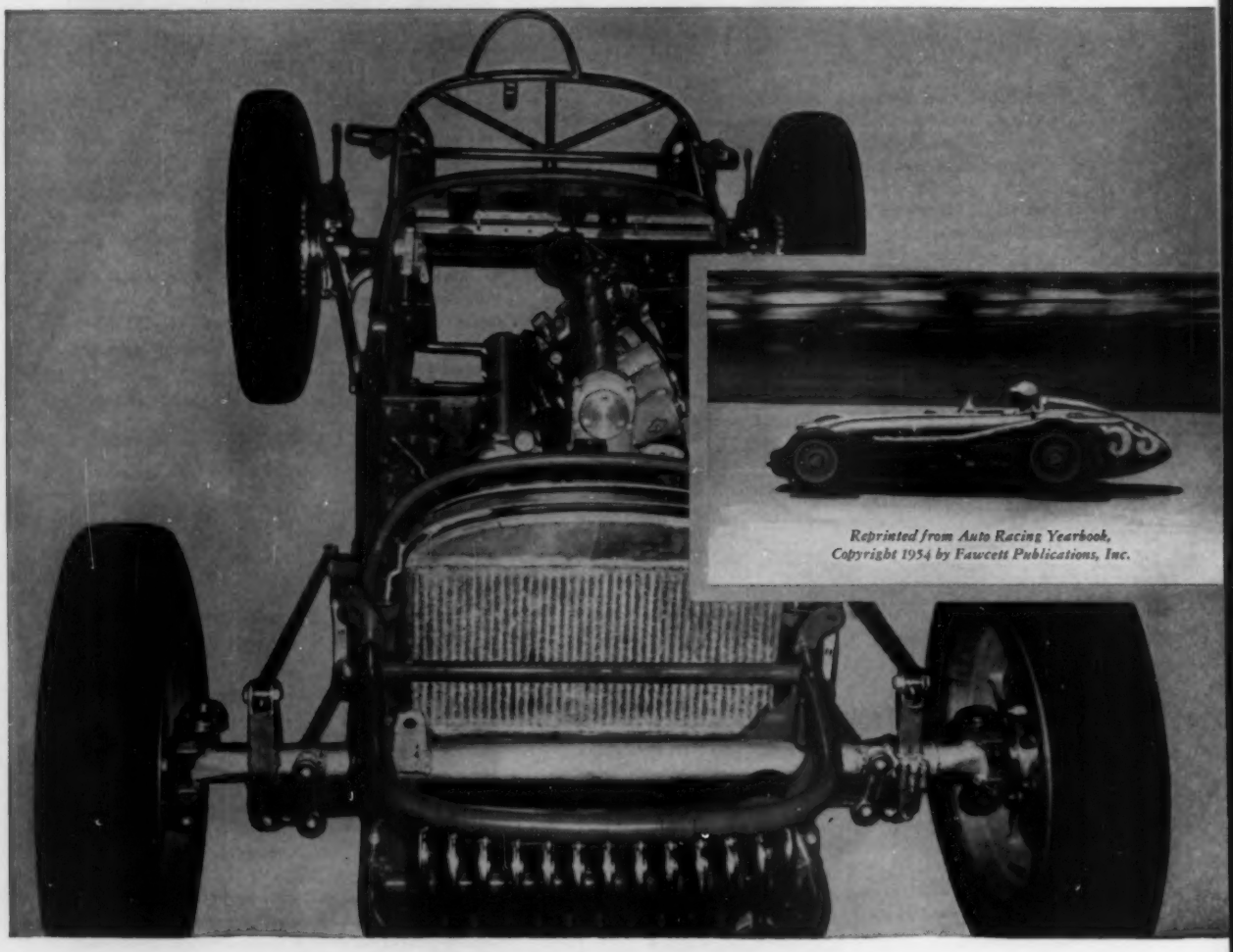
Write for free copy of new "Shell Casting" catalog, today.

CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION • SAGINAW, MICHIGAN • DEPT. 10

WHEN IT'S *MOVING*...MAKE IT *TUBING*

Pound for Pound, Tubular



The body frame of this high-performance racing car is fabricated from steel tubing to obtain maximum strength at reduced weight.

REPUBLIC

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World's Widest Range of Standard Steels

Construction is STRONGEST!

That's why racing-car designers and builders fabricate body frames from steel tubing. A combination of high speed and rugged endurance demands a framework that is both lightweight and strong.

They know that at any given weight, tubing is the strongest of all mechanical shapes—stronger in torsion, stronger as a beam, stronger under compressive loads.

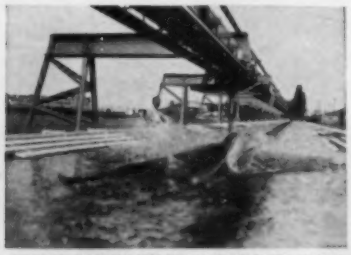
When it comes to a choice, remember: The most economical steel mechanical tubing, dollar for dollar, is Republic ELECTRUNITE®, the *original* electric resistance welded tube. Recognized throughout industry for its exceptional quality, Republic ELECTRUNITE is available in a wide variety of forms, sizes and gages—in both carbon and stainless steels.

Though produced in great volume, every foot in every shipment of ELECTRUNITE tubing is *consistently uniform,* including wall thickness, ductility and concentricity. Surfaces are free from scratches and pit marks. Response to heat treatment is uniform. And it is easy to bend, work with . . . often eliminates costly fabricating or machining operations.

If strength, lightness, safety are requirements in your product, investigate Republic ELECTRUNITE Steel Tubing. Our engineers will help you with design problems, show you the way to greater economies and profits. Send coupon for facts.

MORE REPUBLIC PRODUCTS MADE FOR MOVEMENT:

CYCLIC COMPRESSOR OPERATION REQUIRES AN ABSOLUTE SEAL at the joint between compressor cylinder and head. Republic Alloy Steel Hex Head Cap Screws are made to order for this application because they neither stretch nor lose their grip under the heating and cooling cycle of on-off operation. In fact, they more than meet tensile strength, yield point, hardness and ductility requirements. Republic makes 20,000 standard and 8,000 special types of headed and threaded products for every application. Send coupon for full information.



STRONG RESISTANCE TO CORROSION, WEAR AND ABRASION make Republic Cold Finished Stainless Steel Bars ideal for this unique application. It's a testing tank for advance-type seaplane hulls. Testing is conducted by suspending hull model from carriage which rolls on Republic Stainless Steel Bars. Besides ease of maintenance, these bars provide higher tensile and yield strength, close tolerance, and a fine surface finish, permitting smooth, accurate operation of testing device. Republic metallurgists and engineers will help you apply stainless steel to your present and future work.

TITANIUM PROVIDES STRENGTH AND WEIGHT-SAVINGS in aircraft such as the DC-7. Republic is an old hand at this high strength-to-weight business. We pioneered the use of alloy steels, then stainless steels—followed by high strength steels. Now come Republic Titanium and Titanium Alloys. Years of experience gained in helping hundreds of manufacturers design and re-design their products to get more strength with less weight are available to you. To get more information on how corrosion-resistant titanium can solve many problems, send coupon.

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Cleveland 27, Ohio

Please send more information on:

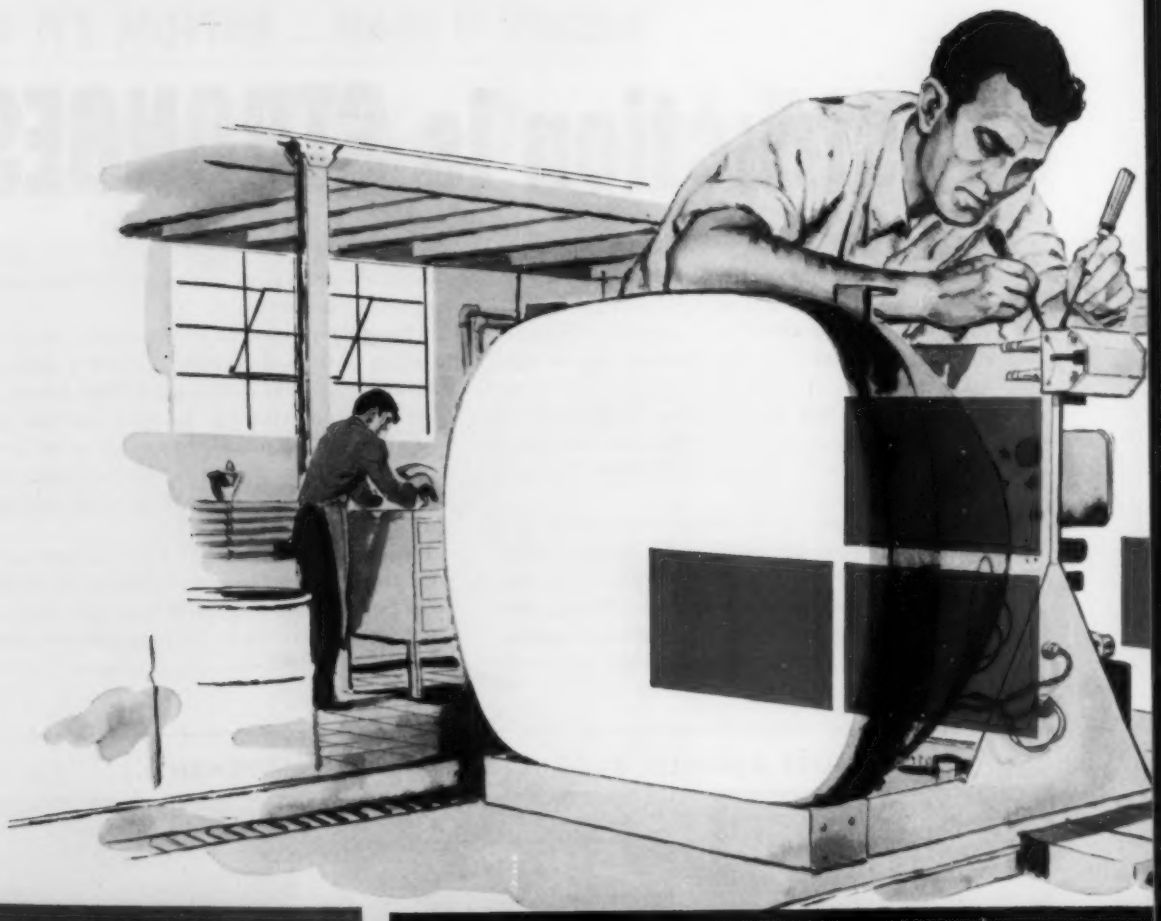
☐ Mechanical Steel Tubing ☐ Stainless Steel
☐ Fasteners ☐ Titanium

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____



new Formica

Exceeds NEMA standards for XXP...meets UL requirements for printed circuitry . . . meets MIL SPEC 3115B for type PBE-P

New Formica Cirprint is far superior to any XXP ever made. The latest product of Formica-4 research, it is the first and only copper clad especially designed to meet the requirements of large volume manufacturers.

Check these Cirprint properties against your requirements:

High IR: 250,000 megohms after 96 hours at 35° C and 90% relative humidity.

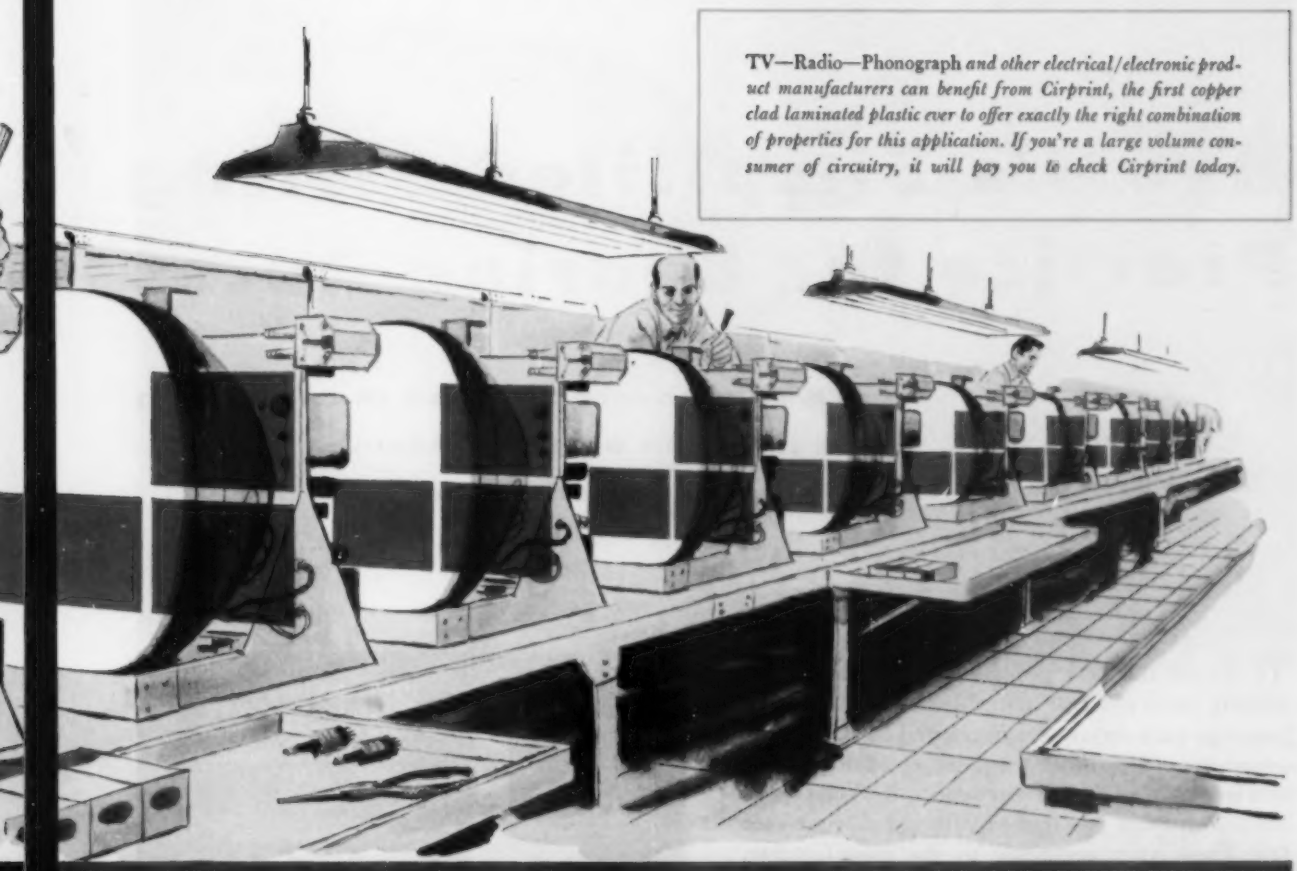
Cold punching: up to and including 1/16".

Low moisture absorption: 0.80% in 1" x 3" x 1/16" sample after 24 hours immersion.

subsidiary of CYANAMID

1st choice in laminated plastics

Application engineering • *Fabricating* • *Research*



TV—Radio—Phonograph *and other electrical/electronic product manufacturers can benefit from Cirprint, the first copper clad laminated plastic ever to offer exactly the right combination of properties for this application. If you're a large volume consumer of circuitry, it will pay you to check Cirprint today.*

CIRPRINT®

Cirprint watermarking gives you quick, positive, visual identification. Eliminates costly and ineffective factory records and marking systems.

You can *see* the quality because Cirprint is translucent. Its smooth structure is free of all impurities. Translucency also permits a visual check on the register of circuits printed on opposite sides of a sheet.

Enthusiastic reports from manufacturers who have tested Cirprint state it's the best XXP ever made . . . and that its outstanding properties are most useful.

Evaluate the contribution Cirprint can make to your electrical/electronic products. Send today for free bulletin 755. Use the handy coupon below, or write Formica Corporation, subsidiary of American Cyanamid, 4516-7 Spring Grove Ave., Cincinnati 32, Ohio.

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4516-7 Spring Grove Ave., Cincinnati 32, Ohio
Please send me a copy of Cirprint bulletin 755.

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Customer stock service

Hyatt's Simplified Fitting Practice for Bearing Races

HYATT pioneered the use of carburizing type alloys in order to obtain the advantages of heavier race fits

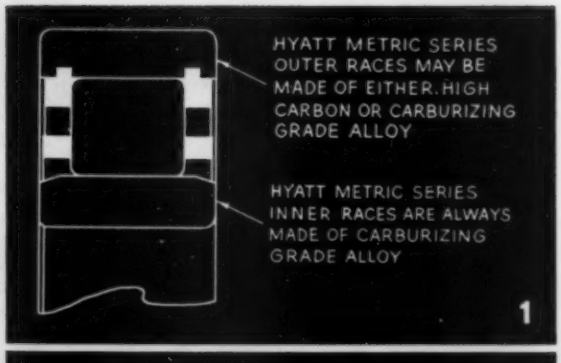
To obtain the best possible performance, roller bearing races must be assembled on shafts and in housings with certain fits developed by design and experience. The most frequent condition to be met is a rotating shaft where specific load and speed conditions must be satisfied with appropriate race fits. These vary according to the manufacturer, and in the case of some manufacturers, according to the application. Naturally, the fits will also vary according to bearing type and size.

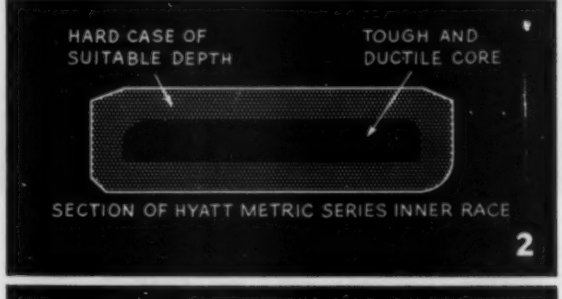
1. CARBURIZING PERMITS HEAVIER INTERFERENCE FITS

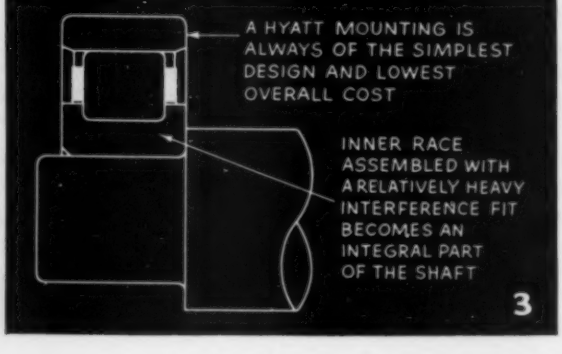
Taking the standard metric series of cylindrical roller bearings for an example, the bearing user has the choice of two fitting practices. One involves the use of inner races made of through-hardening steel, which dictates fairly light interference fits to avoid splitting. The other utilizes races made of low carbon steel *carburized* and hardened to develop a suitable surface hardness and a tough ductile core. The latter permits much heavier interference fits and has the additional advantage of eliminating all auxiliary holding devices, because the race becomes practically an integral part of the shaft. (Figs. 1, 2.)

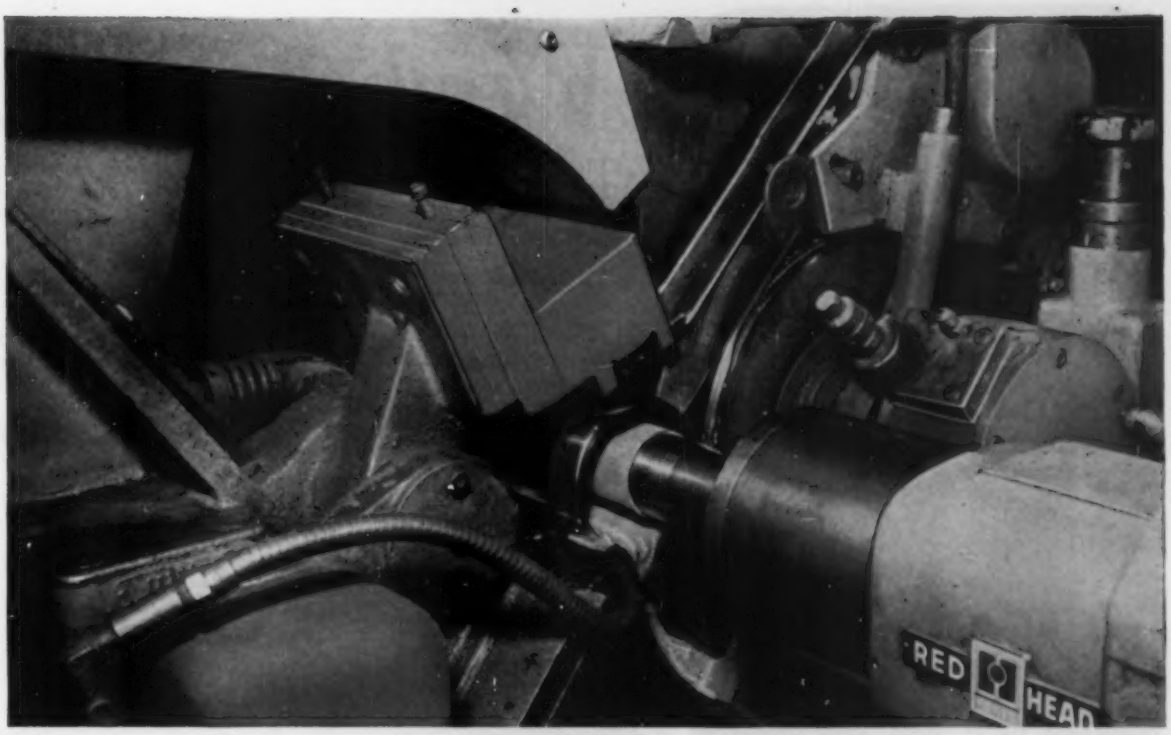
2. HEAVIER FITS SIMPLIFY MOUNTING, REDUCE COSTS

Hyatt originated the carburized race and the system of relatively heavy inner race fits to simplify bearing mounting and eliminate the need for retaining devices. Practically all HYATT inner races are made from nickel alloys of the carburizing type. They permit mountings of the simplest type and lowest over-all cost. Furthermore, the shoulders of HYATT carburized races will withstand considerably greater impact loads than will ordinary races. (Figures 3 and 4.)


HYATT METRIC SERIES OUTER RACES MAY BE MADE OF EITHER HIGH CARBON OR CARBURIZING GRADE ALLOY
HYATT METRIC SERIES INNER RACES ARE ALWAYS MADE OF CARBURIZING GRADE ALLOY
1




A HYATT MOUNTING IS ALWAYS OF THE SIMPLEST DESIGN AND LOWEST OVERALL COST
INNER RACE ASSEMBLED WITH A RELATIVELY HEAVY INTERFERENCE FIT BECOMES AN INTEGRAL PART OF THE SHAFT
3

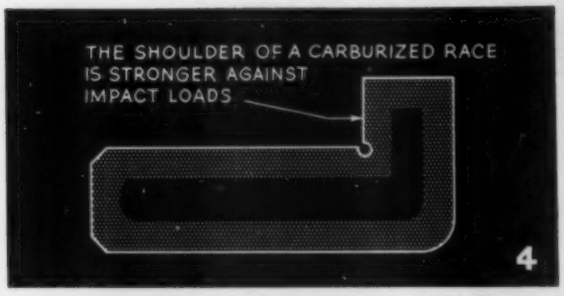


Hyatt inner race being centerless I. D. (inside diameter) ground to close tolerances.

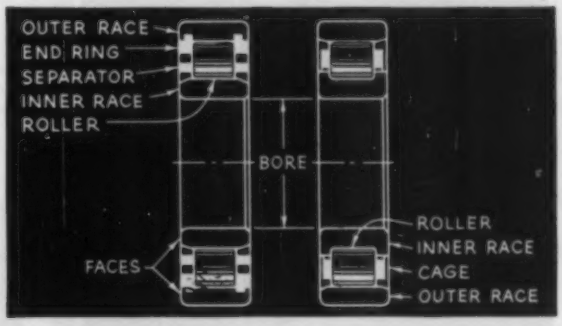
There are two fitting specifications which apply to HYATT inner races, depending on whether the inner race rotates or is stationary in operation. Remember, with both inner and outer race, the rotating member is assembled with heavier fit.

3. HYATT INNER RACES CAN BE EASILY SHRUNK ON SHAFTS

HYATT inner races may be mounted on shafts by pressing or shrinking. Where shrinking practice is employed, first heat the race in oil held at a temperature not over 300°F, or in an electric oven under a similarly controlled temperature, until it expands sufficiently to be slipped into position. The required interference fit will develop as the race cools in place. For special conditions of fit involving hollow shafts of varying sections or multiple housings of dissimilar metals, consult your HYATT Sales Engineer from our nearest sales office.



COMPONENT PARTS OF A HYATT ROLLER BEARING



YOU WILL FIND MORE DETAILS in HYATT Catalog No. 150. If you do not have a copy, write Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey. Sales offices at Harrison, Pittsburgh, Chicago, Detroit and Oakland, California.

GM GENERAL MOTORS

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

WEIGHT TABLE

Dia. or Distance Across Flats	Decimal Equivalent	Shape—Pounds per Linear Foot			
		Aluminum Alloy 2011*		Brass	
		Round	Hexagon	Round	Hexagon
1/16	.0625	.0037	.0042	.0113	.0125
5/64	.0781	.0058	.0066	.0177	.0195
3/32	.0938	.0084	.0106	.0254	.0280
7/64	.109	.0114	.0143	.0346	.0382
1/8	.125	.0151	.0164	.0452	.0499
9/64	.141	.0189	.0209	.0572	.0631
5/32	.1563	.0234	.0258	.0706	.0779
11/64	.172	.0283	.0312	.0855	.0943
3/16	.188	.0337	.0372	.102	.112
13/64	.203	.0396	.0434	.119	.132
7/32	.219	.0460	.0505	.138	.153
15/64	.234	.0526	.0576	.159	.175
1/4	.250	.0600	.0656	.181	.199
17/64	.266	.0677	.0743	.204	.225
9/32	.281	.0759	.0836	.229	.252
19/64	.297	.0846	.0934	.255	.281
5/16	.312	.0937	.1030	.283	.312
21/64	.328	.1034	.1138	.312	.344
11/32	.344	.1134	.1248	.342	.377
23/64	.359	.1239	.1359	.374	.412
3/8	.375	.1349	.1488	.407	.449
25/64	.391	.1466	.1618	.441	.487
13/32	.406	.1582	.1746	.478	.527
27/64	.422	.1709	.1886	.515	.568
7/16	.438	.1837	.2026	.554	.611
29/64	.453	.1965	.2167	.594	.655
15/32	.469	.2109	.2324	.636	.701
31/64	.484	.2246	.2475	.679	.749
1/2	.500	.2398	.2648	.723	.798
17/32	.531	.2707	.2987	.817	.901
9/16	.562	.3036	.3348	.915	1.01
19/32	.594	.3383	.3730	1.02	1.13
5/8	.625	.3748	.4133	1.13	1.25
21/32	.656	.4132	.4557	1.25	1.37
11/16	.688	.4535	.5002	1.37	1.51
23/32	.719	.4958	.5466	1.49	1.65
3/4	.750	.5398	.5951	1.63	1.80
25/32	.781	.5856	.6458	1.77	1.95
13/16	.812	.6335	.6985	1.91	2.11
27/32	.844	.6832	.7528	2.06	2.27
7/8	.875	.7347	.8100	2.22	2.44
29/32	.906	.7880	.8684	2.38	2.62
15/16	.938	.8434	.9288	2.54	2.80
31/32	.969	.9006	.9925	2.72	2.99
1	1.	.9596	1.150	2.89	3.19
1 1/16	1.0625	1.082	1.193	3.27	3.60
1 1/8	1.125	1.214	1.337	3.66	4.04
1 3/16	1.187	1.353	1.490	4.08	4.50
1 1/4	1.250	1.498	1.650	4.52	4.99
1 5/16	1.312	1.653	1.820	4.98	5.50
1 3/8	1.375	1.814	1.998	5.47	6.03
1 7/16	1.438	1.982	2.184	5.98	6.59
1 1/2	1.5	2.159	2.377	6.51	7.18
1 9/16	1.562	2.342	2.583	7.06	7.79
1 5/8	1.625	2.533	2.793	7.64	8.43
1 11/16	1.688	2.732	3.013	8.24	9.09
1 3/4	1.75	2.938	3.240	8.86	9.77
1 13/16	1.812	3.152	3.476	9.51	10.5
1 7/8	1.875	3.373	3.719	10.2	11.2
1 15/16	1.938	3.602	3.972	10.9	12.0
2	2	3.838	4.231	11.6	12.8
2 1/8	2.125	4.333	4.778	13.1	14.4
2 1/4	2.25	4.858	5.356	14.6	16.2
2 3/8	2.375	5.412	5.968	16.3	18.0
2 1/2	2.5	5.997	6.612	18.1	19.9
2 5/8	2.625	6.611	7.290	19.9	22.0
2 3/4	2.75	7.256	8.001	21.9	24.1
2 7/8	2.875	7.931	8.745	23.9	26.4
3	3	8.636	9.522	26.0	28.7
3 1/4	3.25	10.13	11.18	30.6	33.7
3 1/2	3.5	11.75	12.97	35.4	39.1
3 3/4	3.75	13.49	14.89	40.7	44.9
4	4.	15.35	16.94	46.3	51.1
4 1/4	4.25	17.33	19.12	52.3	57.6
4 1/2	4.5	19.43	21.44	58.6	64.6
4 3/4	4.75	21.64	23.89	65.3	72.0
5	5	23.98	26.47	72.3	79.8
5 1/2	5.5	29.11	32.03	87.5	96.5
6	6.	34.54	38.12	104.	115
7	7.	40.02	51.88	142.	156

*Based on density of .02 lb./in.

Work it out!...

TO determine difference in cost between brass and aluminum, first figure total length of part including cut-off width. From weight table calculate pounds required to make 1,000 pieces from brass and from aluminum using this formula.

$$\frac{\text{Wt. per foot of stock X total length of Part X 1,000}}{12}$$

The total material cost for 1,000 parts of both brass and aluminum is then obtained by multiplying pounds required by price per pound* and subtracting value of scrap generated per 1,000 parts.

*ALUMINUM — use per pound price for 2,000 to 4,999 pounds.
BRASS — use per pound price for 10,000 pounds.

ALLOY WEIGHTS

Aluminum Alloy	Density lb./cu. in.	Wt. Conversion Factor
2011	.102	1.00
2017	.101	.99
2024	.100	.98
6061	.098	.96
Brass (free cutting)	.307	3.01

CONVERSION WORK SHEET

STOCK SIZE:_____ PART NO._____

LENGTH OF PART:_____ PART NAME:_____

CUTOFF WIDTH:_____

TOTAL LENGTH:_____

POUNDS OF _____ REQUIRED FOR 1,000 PIECES:

$$\left(\frac{\text{Wt. per foot of stock X total length of Part X 1,000}}{12}\right)$$

_____LBS. @ _____PER LB. = $_____

LESS_____% SCRAP = _____LBS. @ _____/LB. = $_____

COST OF MATERIAL FOR_____PARTS $_____

POUNDS OF ALUMINUM REQUIRED FOR 1,000 PIECES:

$$\left(\frac{\text{Wt. per foot of stock X total length of Part X 1,000}}{12}\right)$$

_____LBS. @ _____PER LB. = $_____

LESS_____% SCRAP = _____LBS. @ _____/LB. = $_____

COST OF MATERIAL FOR ALUMINUM PARTS . . $_____

IN_____ $_____

IN ALUMINUM $_____

SAVINGS PER 1,000 PCS. $_____ _____% SAVINGS

If your job is to design screw machine parts...work out your own examples... see how much you save by converting from brass to Kaiser Aluminum . . . gain advantages in high performance characteristics, less costly handling and shipping, stable material cost, easy machinability with . . .

Kaiser Aluminum

For complete information and expert assistance, call one of our many distributors, or look for our local number in your classified telephone directory.

Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Illinois; *Executive Office,* Kaiser Bldg., Oakland 12, California.

Recommended by Managements

Specified by Designers

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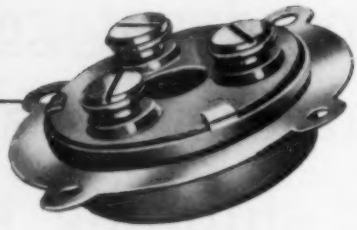
See "THE KAISER ALUMINUM HOUR," Alternate Tuesdays, NBC Network. Consult your local TV listing.

KLIXON

SNAP ACTING THERMOSTATS



USED AS *Standard Controls*

on JANITROL Unit Heaters

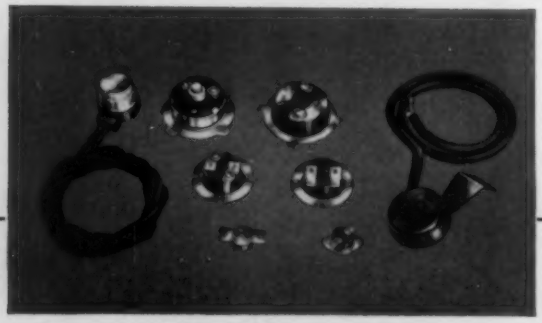
Janitrol Unit Heaters, manufactured by the Janitrol Heating and Air Conditioning Division of Surface Combustion Corporation, are recognized by industry as outstanding for their unusual durability, and during the past 25 years have earned an enviable reputation for customer satisfaction.

Janitrol uses KLIXON Temperature Controls to limit the metal temperatures of the heat exchangers in these unit heaters. Here's what they have to say about KLIXON Controls.

"Many thousands of KLIXON Temperature Controls have been used as standard overheat controls on Janitrol Unit Heaters for twelve years. They have given satisfactory, dependable service."

Typical KLIXON Snap-Acting Thermostats used in many applications, including examples of the new 202 series for home appliances.

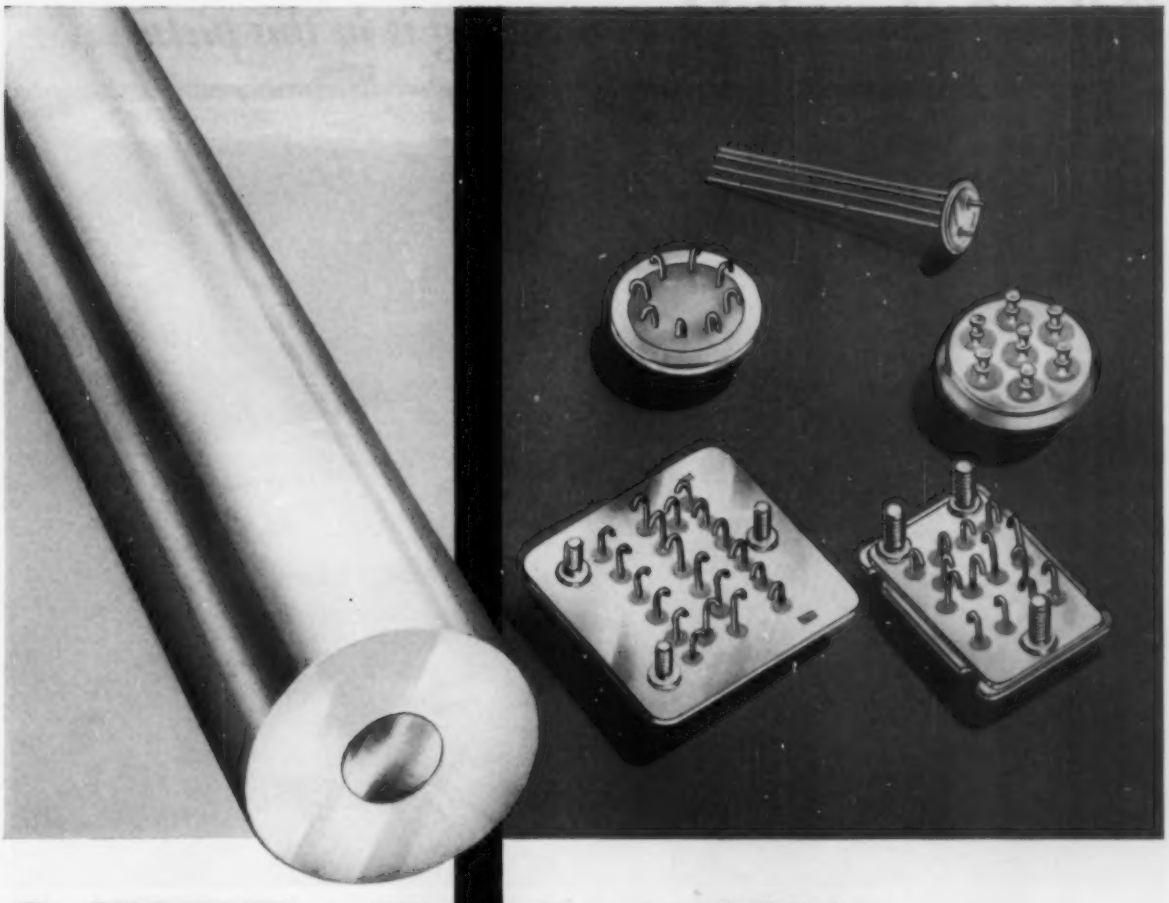
A wide variety of KLIXON Controls, available in hermetically sealed and open types with heavy duty ratings and fixed temperature settings, are successfully meeting difficult requirements in hundreds of military and civilian applications daily.



Why not investigate and see what these simple, inexpensive controls have to offer you in the way of dependable long-life performance? Our Field Engineers will gladly drop in and help you work out application details if you wish — or write us here at the factory if we can assist you in any way. No obligation, of course.

KLIXON®

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
3802 FOREST STREET, ATTLEBORO, MASSACHUSETTS



NEW

General Plate COPPER CORED Glass Sealing Alloy Wire

Increases Electrical Conductivity — Saves Time — Cuts Cost

Here's a case where two metals are much better than one. Built around a 30% copper clad core, General Plate Glass Sealing Alloy Wires have up to three times more electrical conductivity than solid lead wires of the same size.

This means you can substantially increase the current carrying capacity of your solid sealed leads without going to larger diameters — or, if you have a miniaturization problem, you can reduce sealing wire diameters correspondingly by using General Plate Cored Wire.

General Plate Copper Cored Glass Sealing Wires are being used more and more for better performing glass-to-metal seals in hermetically sealed devices such as switches, relays, coils, controls and vacuum tubes.

General Plate Copper Cored Glass Sealing Wires are now available in #52 alloy, Type 446 Stainless, low carbon steel and other glass sealing alloys. Write for Technical Data Bulletin 706.

For full details on the complete line of General Plate Clad Metals, write today for your free copy of our new PR-700A Catalog.

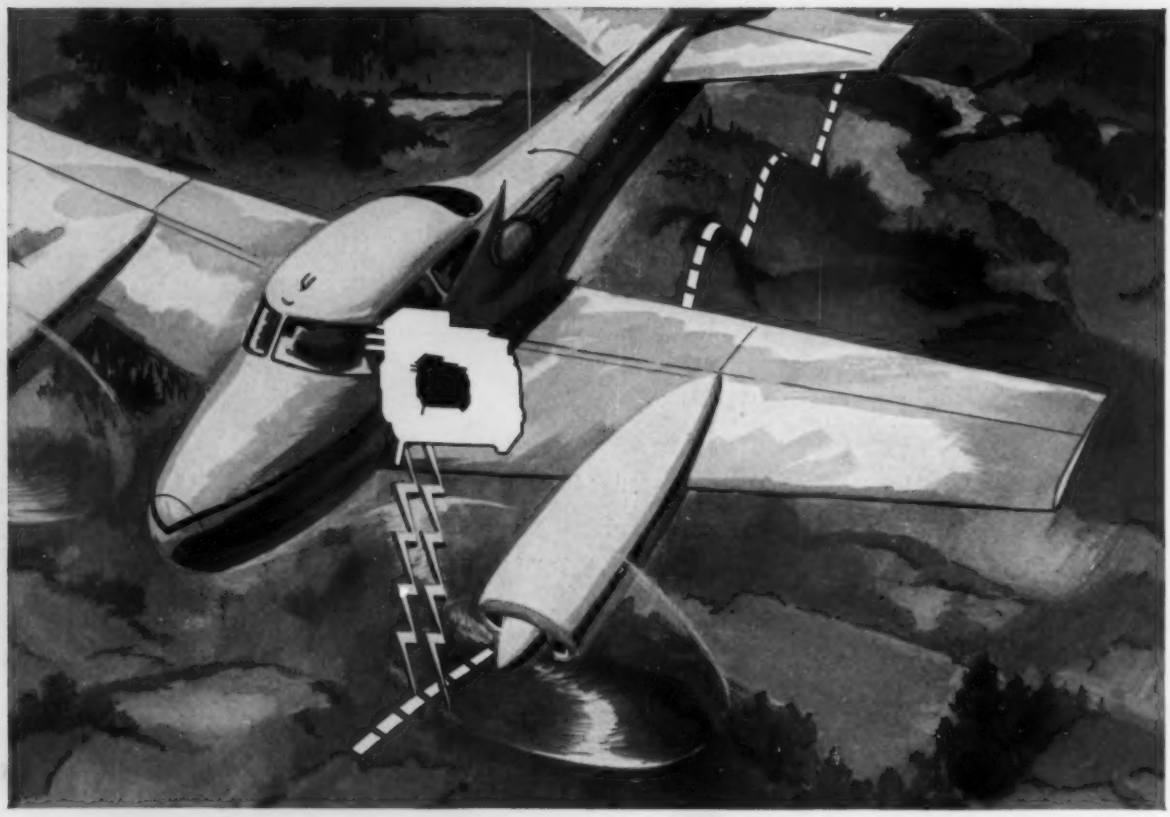
You can profit by using General Plate Clad Metals

METALS & CONTROLS CORPORATION

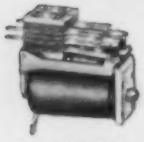
General Plate Division

1002 Forest Street
Attleboro, Massachusetts

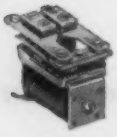
Potter & Brumfield *engineering is in this picture*



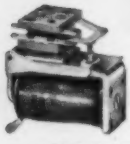
Which P&B relay did Television Associates specify
FOR THEIR AIRBORNE COMPUTER?



MH Series



MB Series



MC Series

Surveys for pipe lines, electric transmission routes and microwave paths are now made from the air, by radar. Television Associates of Indiana, Inc. developed this speedy new technique—and the equipment—which provides clients with detailed profiles of the terrain to be crossed.

Part of the equipment, an intricate airborne computer, requires relays that are fast-acting, light weight, versatile. They must have high shock and vibration resistance and remain operative in temperatures ranging from —45° C to +85° C.

Modified MH relays by P&B were specified. These miniature relays meet all Television Associates' requirements and provide high reliability in a mighty small package. Challenging relay problems are solved daily at P&B. Twenty-five years of creative engineering are behind every P&B relay. Write today for our new catalog.

ENGINEERING DATA

SERIES: MH Miniature Telephone.

CONTACTS: Up to 18 springs, maximum 9 in each stack, forms A, B, C, D, E, X and Y. AC relays are limited to a maximum of 2 poles. Various contact material available.

VOLTAGE RANGE: DC-.05 to 110 V.—AC-6 to 230 V. 60 cycle.

COIL RESISTANCE: 22,000 ohms maximum.

TEMPERATURE RANGE: High temperature range (DC) —55° C. to +135° C.
Standard DC —55° C. to +85° C.
Standard AC —45° C. to +40° C.
Other temperature ranges available to specification.

TERMINALS: Standard pierced solder lug holes will take (2) No. 18 hook-up wires. Adaptable for printed circuits.

ENCLOSURES: Dust cover plus wide range of hermetically sealed covers and types of terminations.

DIMENSIONS: 1-9/16" L. x 25/32" W. x 1⅜" H. (4c Relay).

P&B RELAYS AVAILABLE AT MORE THAN 500 DISTRIBUTORS IN ALL PRINCIPAL CITIES

Potter & Brumfield, inc. PRINCETON, INDIANA

Subsidiary of AMERICAN MACHINE & FOUNDRY COMPANY • Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

DOW CORNING CORPORATION

Silicone News

FOR DESIGN ENGINEERS No. 35

New Pressure Sensitive Tape Has Superior Adhesion at -65 to 500 F

Designers looking for new ways to cut production costs or to improve product performance are certain to find many applications for Permacel EE-3621, a glass-cloth-reinforced tape coated with a pressure sensitive Dow Corning silicone adhesive.

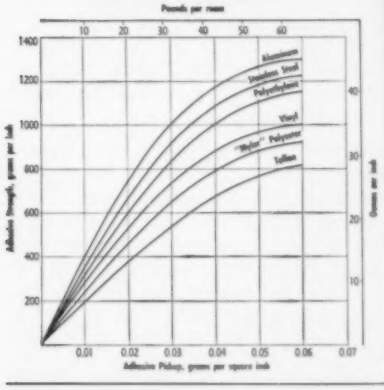
Adhesion values for the new Permacel tape are exceptionally high at extreme temperatures. A 1-inch strip holds—

50 ounces at 150 F
30 ounces at room temperature
74 ounces at —65 F

The tape remains tacky and flexible at —65 F and does not become hard or brittle in service at 500 F. It retains excellent moisture resistance and dielectric strength at all temperatures.

Permacel EE-3621 is supplied with a corrugated glass cloth backing to minimize slippage of wire bundles in the production of electrical components. (Cont. Pg. 2)

TYPICAL ADHESIVE STRENGTH OF EE-3621 ON VARIOUS SURFACES



SILASTIC HELPS MEAT THERMOMETER TAKE GUESSWORK OUT OF ROASTING

Because Silastic* stays rubbery and retains its dielectric properties at temperatures from —130 to 500 F, its use is expanding in many industries. New applications for Dow Corning's silicone rubber range from jet aircraft to this electric meat thermometer developed by King-Seeley Corporation, Ann Arbor, Michigan.

A highly practical tool for professional and amateur cooks alike, King-Seeley's meat thermometer consists basically of a thermistor sealed inside a probe. When inserted into a roast, the thermistor quickly translates meat temperature into electric current which indicates on a dial the degree to which the meat is "done."

Silastic is used to cover the flexible lead wire running to the probe because it remains resilient and retains good dielectric properties despite frequent and sometimes lengthy exposure to 500 F oven temperatures. In addition, since Silastic transmits neither odor nor taste even at these high temperatures, two spring-compressed Silastic washers seal the probe and prevent contamination of the thermistor.

Philco was first to offer the King-Seeley thermometers on kitchen ranges, under the

*T.M. REG. U.S. PAT. OFF. (Cont. Pg. 2)

Silicone Enamel Survives 1000 F In Space Heater Tests

A mishap during a recent high temperature test on space heater finishes dramatically emphasized the superior serviceability of silicone based paints and enamels.

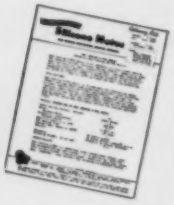
The top surface grill of the space heater being tested was finished with an enamel formulated with a modified Dow Corning silicone resin. "Cooler" areas of the unit—sides and front — were coated with an organic paint.

During the heat test, an oven thermostat failed. Temperatures soared to an estimated 1000 F where they stayed for several hours before the trouble was discovered. By then, the following changes had taken place— (Cont. Pg. 2)

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



All New — 1957 Guide to Dow Corning Silicones is a twelve page, fact-filled catalog which briefly describes the silicone products of interest to most industries. Containing latest data and information, the guide is designed expressly to help you realize the advantages, profits, and savings made possible through imaginative use of these unique engineering materials. *No. 361*

Dow Corning Silicone Lubricants, including oils and greases, are described in a new, illustrated 8-page brochure that gives their properties, lists typical applications, and cites factors which contribute to obtaining longer life. *No. 362*

Encapsulating Electrical and Electronic Parts with Silastic, a recently published data sheet, gives details for using two types of Silastic to protect parts against dust, moisture, oxidation, mechanical injury, weathering, and corrosive attack. *No. 363*

Distributors who carry Class H insulating materials in convenient local warehouse stocks, are listed in a revised source of supply sheet. *No. 364*

Engineering brochure on Silastic 50 and 80; includes detailed information on these two general purpose silicone rubbers; provides a convenient reference for design and production engineers. *No. 365*

Documentary film "What's a Silicone?" available free of charge for showings to technical audiences in every industry. In full color and sound, this dramatic 16 mm film allows you to see Dow Corning Silicones in action improving the performance of products ranging from nursing bottle nipples to diesel locomotives. For more information about this educational film and how to arrange a showing for interested persons in your plant, circle ..... *No. 366*

Accuracy Of Timer Assured With Silicone Damping Fluids

Exhibiting remarkably little change in viscosity at temperatures ranging from —70 to over 400 F, silicone fluids have helped engineers design greater dependability into many modern instruments. One interesting new application is found in the "Timelok" manufactured by the Euclid Electric & Manufacturing Company, Madison, Wisconsin.

An integral timing device for controlling d-c motor starters and controllers, Timelok relies on the consistent damping force of Dow Corning 200 Fluid to provide long time accuracy despite temperature variation.

The Timelok timer consists basically of a steel piston inside a hermetically sealed cylinder filled with Dow Corning 200 Fluid. When a coil is energized, magnetic flux pulls the piston through the silicone fluid.

To quote Euclid engineers, "Fraction-of-an-inch movement of a piston within a chamber of silicone fluid constitutes the simplest form of mechanism possible and contributes to the long life of the timer. Silicone fluid offers a distinct advantage over the best petroleum oils because of its very low change in viscosity with varying temperatures. The fluid is also extremely stable and will not break down to form gummy or solid substances."

Timeloks are available in time intervals ranging from 0.2 to 10 seconds, depending on the viscosity of the 200 Fluid employed. Each can be further adjusted manually in a 6 to 1 ratio and all are interchangeable within any contactor.

Euclid designers have always relied exclusively on silicone fluids for dependable damping. They are so confident of the reliable operation of every Timelok that they have a standing offer to replace without cost any timer that fails to outlast the contactor with which it operates. *No. 358*

SPACE HEATER *(continued)*

(1) The organic finish was completely destroyed. All trace of the binder was gone and the dry pigment still adherring to the surface brushed off on contact. The metal under the organic finish had turned blue-black.

(2) In contrast, the grill finished with a silicone resin finish still retained 95% of its original coating. The finish was still well bonded and no noticeable change of color had taken place to mar its original attractiveness.

Comparative tests on special panels later confirmed these findings in the laboratory. After 5 minutes exposure to 800 F, the organic finish had lost all of its binder; after 30 minutes at the same temperature, the silicone finish was still firmly bonded, showed only moderate color change, and still provided maximum protection to the metal underneath. *No. 357*

PRESSURE SENSITIVE TAPE *(continued)*

Although designed for use in Class H motors and transformers, the silicone adhesive permits EE-3621 to be used for many taping applications where extreme temperatures are the order. *No. 359*

MEAT THERMOMETER *(continued)*

trade name "Roastmeter." Hot Point, Magic Chef, and Cribben & Saxton ranges also feature it now. Other manufacturers have either arranged to include the meat thermometer in their line or are considering its early adoption. *No. 360*

Dow Corning Corporation, Dept. 0614, Midland, Michigan

Please send me: 357 358 359 360 361
362 363 364 365 366

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SILICONE NEWS is published for product design and development engineers by

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DOW CORNING CORPORATION
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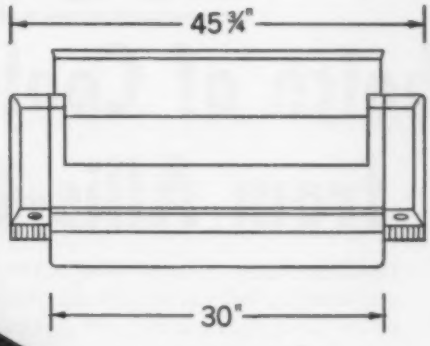
At Last! A Small Whiteprinter that Makes BIG Prints!



FULL 30-INCH PRINTING WIDTH!

NEW! BRUNING Copyflex Model 300!

Brings "Inside" Reproduction within the Means of the Smallest Engineering Firm or Department!
Now, with your low-cost, versatile Model 300, you can make high quality prints when you want them—rapidly, privately, and in any quantity. You can exercise complete control over valuable originals at all times.

Provides Large Companies an Economical Way to Supplement Main Reproduction Centers!
With its compact size, big printing width, and low cost, the Model 300 is an ideal helper for your big reproduction machine. Strategically located throughout your company, Model 300s can bring new speed, convenience, and efficiency to your reproduction operations.

Here it is! The compact, low-cost reproduction machine that offers all the versatility and big printing width of a large, expensive whiteprinter!

Just think—you can make sharp, black-on-white prints in seconds of a drawing or tracing up to 30 inches wide by any length. And anyone can operate the Model 300 after only brief instruction. One fingertip control turns the machine on or off and regulates its speed. Exposure and development are automatically synchronized.

The new Copyflex Model 300 is ideal for drafting rooms and offices because it can be operated anywhere without annoyance to personnel in the vicinity. It is clean, quiet, and odorless. No exhaust venting, plumbing, or accessory equipment required. It needs only a connection with a 115-volt AC outlet for operation.

If you're pressed by the boom in production for more and more engineering prints, the all-new Copyflex Model 300 is your answer! Its low initial cost combined with outstanding economy and convenience of operation and maintenance make it your soundest, low-cost investment of the year. Mail coupon today! You'll be glad you did!

BRUNING Copyflex

Best Process! Best Machines! Best Selection of Materials!

Offices in 37 Cities of the U.S. and Canada

CHARLES BRUNING COMPANY, INC., 4700 MONTROSE AVE., CHICAGO 41, ILL.
In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

CHARLES BRUNING CO., Dept. 23-0
4700 Montrose Ave., Chicago 41, Ill.

Please send me information on the all-new Copyflex Model 300.

Name_____ Title_____

Company_____

Address_____

City_____ County_____ State_____

MORE choice of Coolant Pumps from Allis-Chalmers

Broaches, lathes, drills, grinding and boring machines . . . whatever machine tool you build or use, Allis-Chalmers has a coolant pump that's *just right* for your application. When you specify Allis-Chalmers, you get:

1. Choice of mounting — Complete line permits *six* different mounting methods — makes your design job easier.

2. Choice of sealing — Depending on your requirements, you can specify mechanical seals (if clear liquids are pumped), or sealless construction (where gritty and abrasive particles are in liquid).

3. Choice of impeller — Single-suction impellers are available in either enclosed or open design—double-suction, open design.

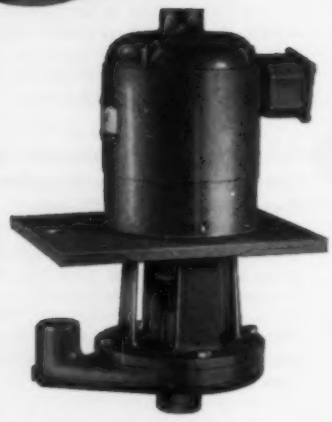
Pump Experts from Allis-Chalmers can help you with your application. Contact your nearby A-C sales office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

MOUNTED ON DRILLING MACHINE, this A-C pump is sidewall mounted, is sealless, and has open impeller.

AVAILABLE in fractional horsepower and integral sizes, above model is designed for mounting on vertical surface.

VERTICALLY MOUNTED on liquid reservoir, this design operates efficiently with varying liquid levels. Available in four optional discharge positions.

SUBMERGED MOUNTED, this type of pump is frequently used on machines requiring mounting in coolant tank.



SHALLOW SUMP or reservoir use is ideal for this submerged mounted model featuring a sealless design.

A-C ALLIS-CHALMERS

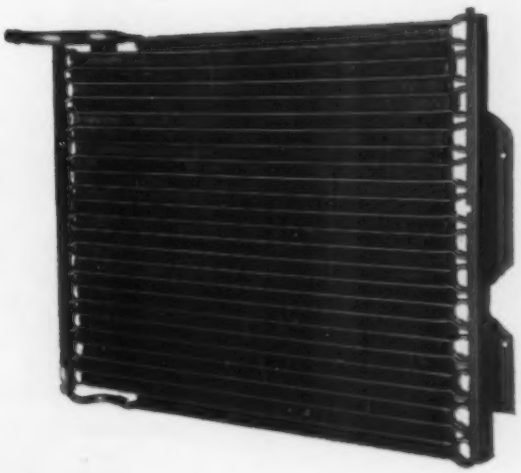
ALLIS-CHALMERS

A-5201

Hot and bothered by tubing problems?

NEW GM STEEL TUBING "FLATTENED SERPENTINE" HELPS HARRISON COOL AIR BY THE CARLOAD

New Harrison Air Conditioning Systems for the '57 GM line use new "flattened serpentine" condensers of GM Steel Tubing. This exclusive development provides more contact area for a better bond, lets less tubing handle a higher heat-transfer volume . . . cuts size and weight, boosts efficiency and strength. It's another GM Steel Tubing "first"... and typical of the resourceful engineering service that's ready to go to work on *your* product problems. Check Sweet's Product Design File 1a/Ro, write us direct or call your Rochester Products Sales Engineer.



GM STEEL TUBING BY ROCHESTER PRODUCTS

ROCHESTER
PRODUCTS
DIVISION OF
GENERAL MOTORS
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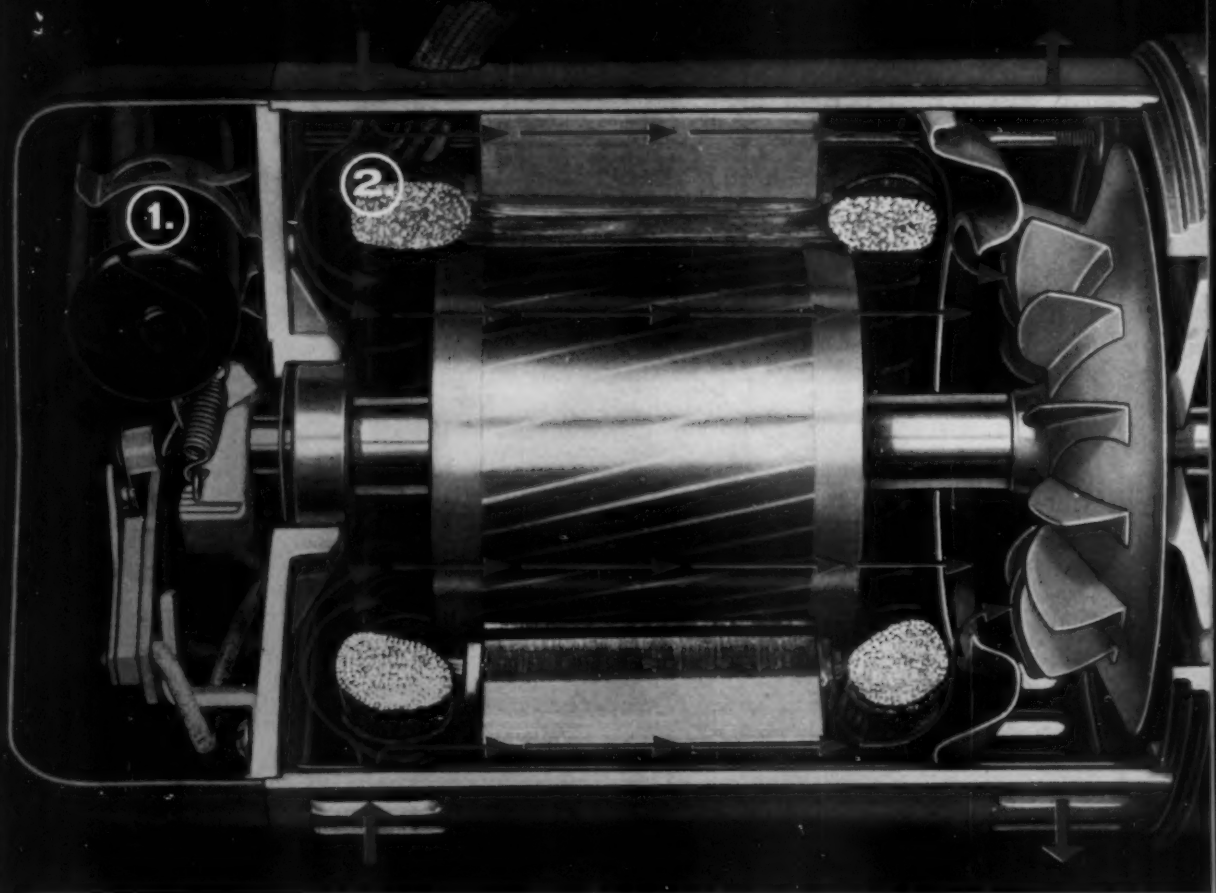
NOW! TRULY

1. TOTALLY ENCLOSED FUNCTIONAL PARTS

2. CONTROLLED VENTILATION THROUGHOUT WORKING PARTS



Totally enclosed functional parts

Motor switch, starting capacitor and automatic overload protector stay *totally* free from dust, dirt and other foreign matter. Tough steel canopy resists abuse . . . provides vital protection that adds years of motor service life.

Controlled end ventilation

Generous intake and discharge louvers, large fan mounted on shaft, and plenty of space back of stator core assure uniform cooling of windings and rotating parts. Air flow is aimed at the coils . . . eliminating recirculation of exhausted heat, providing greater cooling.

Shielded ball bearings are permanently lubricated—bearing failures virtually eliminated.

Formvar insulated stator windings—Double-dipped in insulating varnish and baked to a hard finish for maximum corrosion resistance.

Mylar slot and phase insulation—Finest available. Mylar is rag-paper backed for puncture protection.

Die-cast aluminum rotor is dynamically balanced to minimize vibration . . . sets new silent-running standards.

DIFFERENT FRACTIONALS

Providing a new yardstick for motor buying— these A. O. Smith fractional hp motors have been proved superior by more than 1,000,000 units in tough stop-and-go service

Cutaway view tells you a story that no other manufacturer of fractional hp motors can equal. From canopy to base plate — here's exclusive functional design *proved* by more than a million units in tough jet pump service—now ready to provide a new measure of performance in your own products.

Here are key reasons why these uniquely different fractionals let you design years of trouble-free service in *any* horizontal or vertical application. By *totally enclosing* all functional parts and *controlling the ventilation* of all working parts — A. O. Smith gives you protection never before possible in motors of this size at no extra cost.

Available in single and 3-phase fractionals of ⅓, ½, ¾ hp and also 1 and 2 hp ratings . . . with torque, speed and operating characteristics perfectly matched to the needs of your equipment. For truly different fractionals, see A. O. Smith!

Resilient base design with external capacitor.
Rigid base with optional overload protector.
Totally enclosed, fan-cooled type.

Functionally grouped, totally enclosed components—All end-mounted and under dust-free steel canopy which may be easily removed for servicing. Starting switch is an exclusive A. O. Smith development — snap-action assures positive contacts at all times.

Vertical or horizontal application — Design engineers will quickly appreciate how readily A. O. Smith fractionals can be adapted to processes or products. Special interchangeable canopies for either vertical or horizontal installation. Mountings to suit your needs.

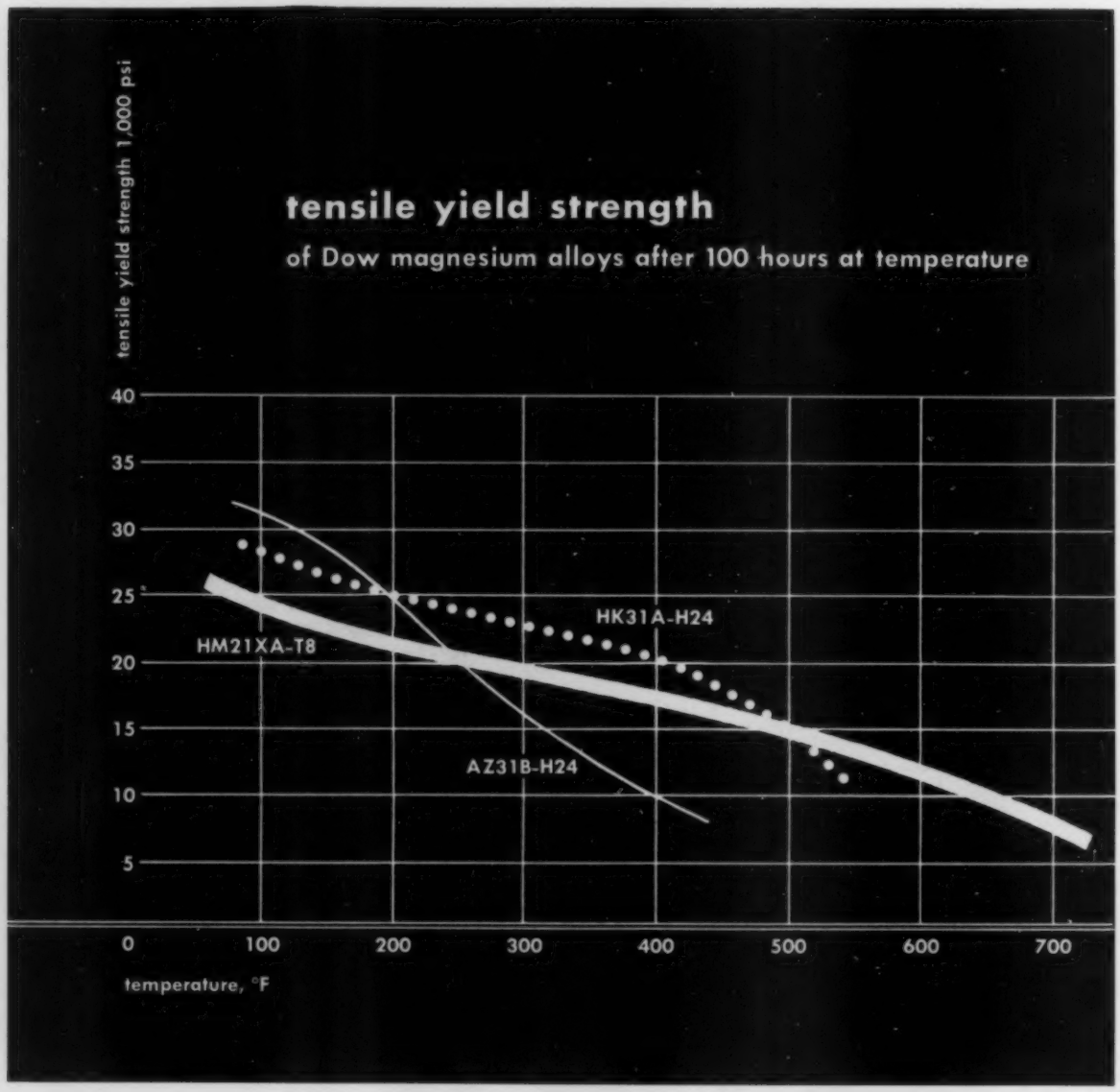
Engineered to your equipment — A. O. Smith fhp motors are offered with many variations, some of which are end frames, mounting brackets, capacitor locations and shaft lengths to meet both standard and custom requirements. Ball bearings are standard to allow horizontal or vertical operation.

Whatever your needs — fractionals (⅓ to 2 hp range) — application-engineered integrals (1 to 150 hp) or hermetics (1½ through 10 hp), you'll find it pays to contact A. O. Smith first. Get all the facts. Write A. O. Smith Corporation, Electric Motor Division, Tipp City, Ohio.

Through research A.O. Smith *. . . a better way*

A.O.Smith
CORPORATION

ELECTRIC MOTOR DIVISION
Tipp City, Ohio
International Division: Milwaukee 1, Wisconsin



New magnesium alloy holds properties for 100 hours up to 700°F.

Dow Magnesium HM21XA-T8 alloy extends further the range of conditions under which light metals can be used in aircraft design. Second in the series of sheet alloys designed specifically for elevated temperature applications, it supplements the excellent characteristics of HK31A alloy.

HM21XA-T8 retains its properties at temperature during long periods of time. Even one hundred hours at 700°F. results in relatively little change in tensile yield, creep and elastic modulus.

Magnesium lightness is combined with strength at elevated temperature in HM21XA-T8, offering new ways to save weight or gain increased rigidity in the design of missiles and aircraft. This alloy is supplied in the -T8 temper and can be formed in this temper without the need for further heat treatment after fabricating. Samples of HM21XA-T8 along with detailed information are available. Contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1400H.

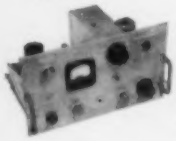
YOU CAN DEPEND ON DOW

TECHNIQUES and DEVELOPMENTS in oscillographic recording

FROM SANBORN

PHASE SENSITIVE DEMODULATOR PREAMPLIFIER PROVIDES A DC VOLTAGE PROPORTIONAL TO AN INPHASE COMPONENT OF AN AC VOLTAGE WITH RESPECT TO A REFERENCE.

THE measurement of the amplitude of an AC voltage component is often necessary in performance studies of servo systems or of suppressed carrier signals over the carrier frequency range from 60 to 10,000 cps. In such cases the demodulator responds to inphase signals and rejects quadrature signals.



A circuit with these characteristics for use in an oscillographic recording system can be seen in the Model 150-1200 Servo Monitor (Demodulator) Preamplifier. It was developed by Sanborn as one of twelve interchangeable, plug-in front ends for "150" Series equipment, to be used with the appropriate Driver Amplifier-Power unit in any channel of a "150" system. Elements comprising the circuit from input to output, include: compensated stepped attenuator and cathode follower input circuit, phase inverter, push-pull mixer and demodulator stages, differential DC output amplifier and low pass filter. In addition, the chassis contains a VTVM to facilitate accurate adjustment of the reference voltage, and an overload indicator which lights a warning lamp when excessive quadrature voltages exist.

Adaptability to a fairly wide variety of applications is accomplished through broad input voltage, reference voltage and frequency ranges. In order, these are 50 mv to 50 v (for full scale 5 cm deflection), 10 v to 125 v; 60 cps to 10kc. Rise time with low frequency plug-in demodulation filter is 0.1 seconds; with high frequency filter, 0.01 seconds. Quadrature rejection is better than 100.1; for carrier frequencies up to 5000 cycles.

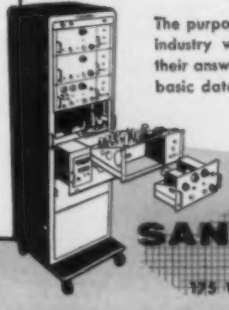
Two representative uses of the Servo Monitor Preamplifier are in the design and adjustment of servo systems, and with instruments used in the design, development or adjustment of other apparatus. The first is illustrated by use of the Preamplifier and associated equipment in the recording of the output shaft amplitude and driving frequency of an AC positional servo; the second by recordings made with a similar setup of the difference between output signals from a gyroscopically-controlled stabilizing device and the "pitch" and "roll" signals generated by a "Scorsby Table" used for testing the device under dynamic conditions.

For a detailed discussion of the principles and design considerations involved in the Servo Monitor Preamplifier, refer to the February, 1955 issue of the Sanborn RIGHT ANGLE, for Dr. Arthur Miller's article on "Measurements with the Servo Monitor Preamplifier."

Technical literature and engineering assistance on specific problems are always available from our engineering department.

BASIC FACTORS IN SELECTING OSCILLOGRAPHIC RECORDING EQUIPMENT

WHEN considering any oscillographic system or equipment for your application, three useful "yardsticks" to apply are (1) the recording method, (2) equipment adaptability, and (3) variety of equipment available. Here are the answers to the three, as they apply to Sanborn systems. In the record, rectangular coordinates accurately correlate multiple traces, simplify interpretation and eliminate errors. Permanent traces, produced by a hot ribbon stylus without ink, provide sharp peaks and notches, and clearly reveal all signal changes. One percent linearity results from current feedback driver amplifiers and high torque galvanometers of new design; maximum error is ¼ mm in middle 4 cm of chart, ½ mm across entire chart. From the standpoints of "adaptability" and "variety", Sanborn "150" equipment offers the versatility of 13 different plug-in front ends for any basic system . . . the choice of one- to eight-channel systems . . . the variety of nine chart speeds, timing and coding controls, console or individual unit packaging . . . availability of equipment as either complete systems or individual amplifier or recorder units.



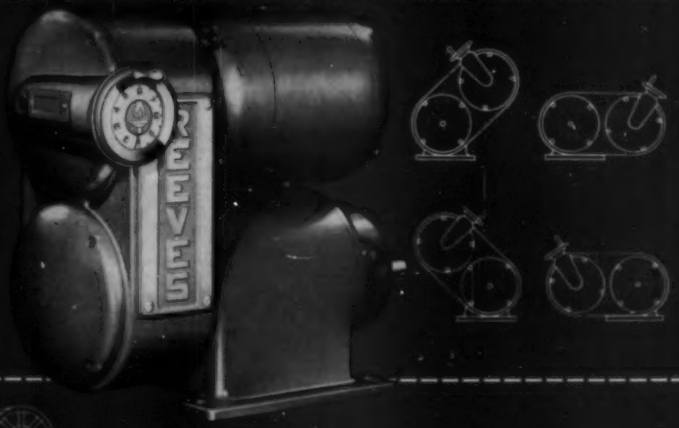
The purpose of the foregoing information is to better acquaint industry with typical oscillographic recording problems and their answers, design considerations in Sanborn equipment, and basic data on what Sanborn makes and how it is being used.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 WYMAN STREET, WALTHAM 54, MASS.

REEVES®

the one name for all mechanical variable speed!

REEVES Vari-Speed® Motodrive

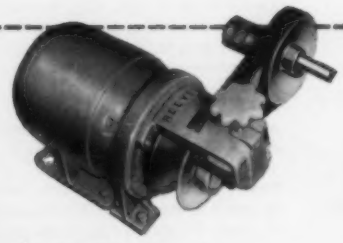


REEVES Vari-Speed® Motor Pulley

REEVES Variable Speed Transmission

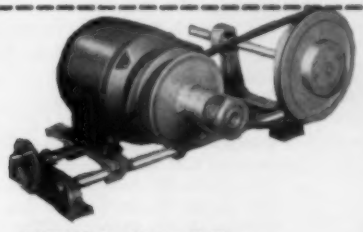
● The *complete line* in the industry is REEVES . . . adjustable speed drives and speed control for applications from ⅛ to 37 hp! The *proven* name is REEVES . . . years of trouble-free service in hundreds of thousands of installations—every industry! The *original* variable speed drive, REEVES is still the leader in its field!

Incorporate variable speed into the machines *you* design: widen the work range of the machines; insure your designs against early obsolescence; add the many operating advantages of accurate, instant speed control. Your REEVES representative—with wide and varied experience—will be glad to work with you for the *best* application . . . *best* results!



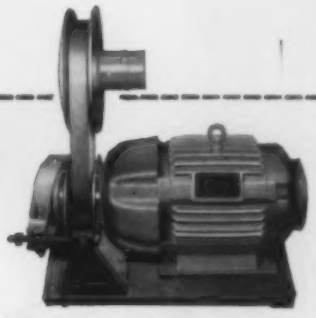
REEVES Flexi-Speed

Two sets of adjustable discs with convenient shifting mechanism. Provides flexibility, economy to your equipment . . . easy to install. ½, ¾ and 1 hp. with 8:1 speed ratio.



REEVES Jr. Motor Pulley

Simplest form of variable speed control. 5 sizes from ⅛ to 1½ hp. capacity . . . ratios up to 2.75:1 in a speed range from 135 to 1965 rpm. Standard or countershaft bases for standard motors.



REEVES Vari-Spin

A mill tested and proved unit to increase spinning efficiency and frame flexibility. 500 to 1450 rpm. range. Change speeds *with spinning frame in operation* . . . get required speed—in seconds!

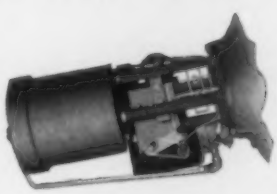
REEVES CONTROLS

Manual

Basic REEVES control on all units. "Speedial" handwheel, extended handwheel, hand chain and extended rod controls also available.

***Mechanical Automatic**

For Motodrive, Transmission. Simplest automatic control—requires shifting force sufficient to position control lever of speed changing mechanism.



Automatic (Pneumatic)

Motodrive application only. Cam-compensated design controls output speeds in direct proportion to instrument air signals.

Electric Remote

Push-button stations for single unit or battery of Motodrives, Transmissions or Motor Pulleys. AC or DC . . . full range of current characteristics.

*Also available in hydraulic or pneumatic type.

Individual bulletins—complete with rating tables and dimensions—are available for any of the above products by writing REEVES, Dept. K26b. Columbus, Indiana.

Your REEVES representative will be glad to work directly with you. He's as near as your telephone . . . regional offices in 34 principal cities.

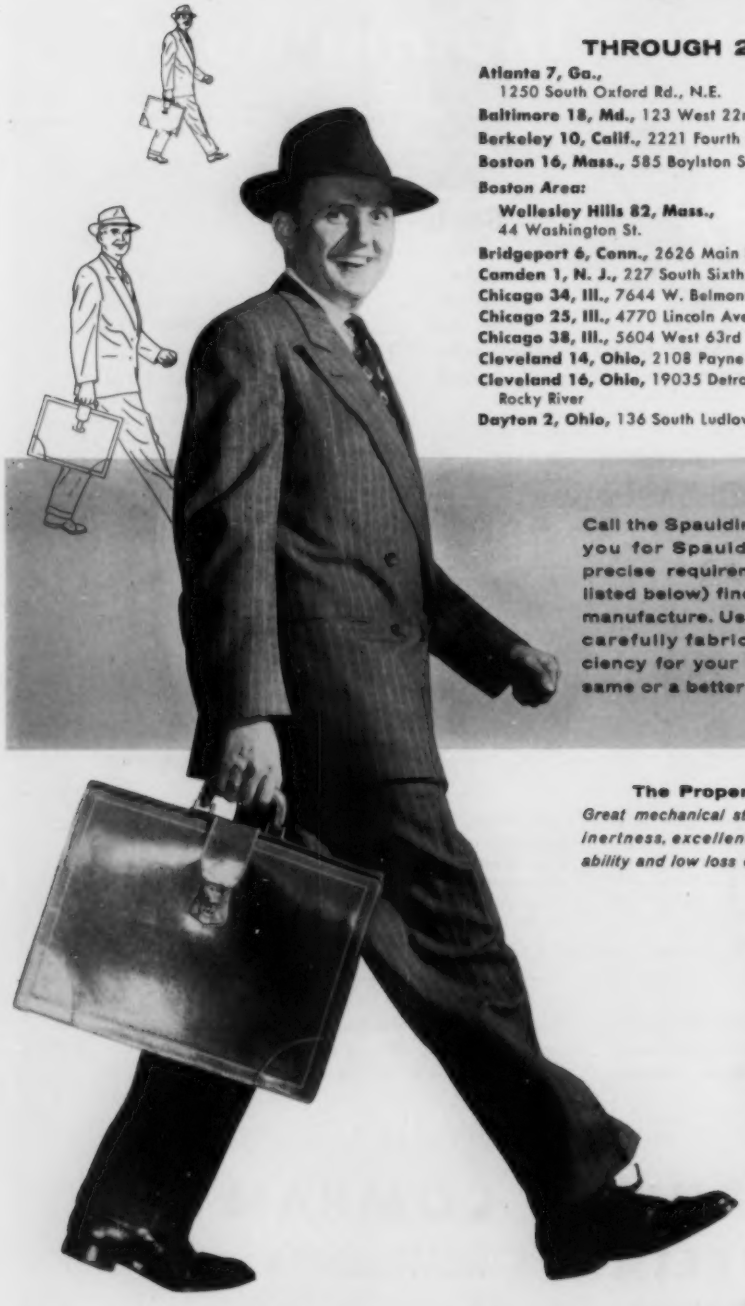
REEVES PULLEY COMPANY

DIVISION OF **RELIANCE** ELECTRIC AND ENGINEERING CO.

COLUMBUS, INDIANA

Spaulding

Gives **PROMPT, PERSONAL ATTENTION** to *your* problems



THROUGH 26 BRANCH OFFICES

Atlanta 7, Ga., 1250 South Oxford Rd., N.E.
Baltimore 18, Md., 123 West 22nd St.
Berkeley 10, Calif., 2221 Fourth St.
Boston 16, Mass., 585 Boylston St.
Boston Area:
Wellesley Hills 82, Mass., 44 Washington St.
Bridgeport 6, Conn., 2626 Main St.
Camden 1, N. J., 227 South Sixth St.
Chicago 34, Ill., 7644 W. Belmont Ave.
Chicago 25, Ill., 4770 Lincoln Ave.
Chicago 38, Ill., 5604 West 63rd St.
Cleveland 14, Ohio, 2108 Payne Ave.
Cleveland 16, Ohio, 19035 Detroit Rd., Rocky River
Dayton 2, Ohio, 136 South Ludlow St.
Detroit 1, Mich., 4612 Woodward Ave.
Fort Wayne 6, Ind., 2301 Fairfield Ave.
Lansing 10, Mich., 2021 South Cedar St.
Long Island, N. Y., 90-34 Jamaica Ave., Woodhaven 21
Los Angeles 15, Calif., 1325 San Julian St.
Milwaukee 8, Wisc., 3329 West Vliet St.
Newark, N. J., 101 Central Ave., Westfield, N. J.
New York 55, N. Y., 384 East 149th St.
St. Louis 5, Mo., 7247 Olive Street Road
St. Louis 17, Mo., 1500 Big Bend Blvd.
Syracuse 3, N. Y., 1206 East Water St.
Tonawanda, N. Y., 310 Wheeler St.
Toronto, Ont., 106 Lake Shore Drive E. Port Credit, Ont.

Call the Spaulding man at the Branch Office nearest you for Spaulding materials fabricated to your precise requirements. Spaulding products (they're listed below) find application in almost every field of manufacture. Use these versatile materials and parts carefully fabricated in our plant, for greater efficiency for your products without extra cost, or; the same or a better job at lower cost.

The Properties of Spaulding Materials Include

Great mechanical strength, extremely light weight, durability, chemical inertness, excellent machining qualities, arc resistance, deionizing ability and low loss electrical insulation.

WE MAKE AND FABRICATE

VULCANIZED FIBRE: In sheets, rods, tubes and fabricated parts.
ARMITE: Thin Insulation (Fish Paper) in sheets, rolls, coils and fabricated parts.
SPAULDITE: (Laminated Thermosetting Plastic) in sheets, rods, tubes and fabricated parts.
SPAULDO: Motor Insulation in sheets, rolls, coil, slot cells and other fabricated parts.
SPAULDING FIBRE BOARD: In sheets and fabricated parts.
SPAULDING T BOARD: A superior Transformer Board in sheets and fabricated parts.
MATERIALS HANDLING EQUIPMENT: Factory Trucks Boxes, Barrels, Trays, etc.
SPAULDING FABRICATING FACILITIES: Spaulding's fabricating facilities for these products are unsurpassed the world over. You can save time and money by letting us do your fabrication. We'll be glad to quote on specific jobs without obligation.

Spaulding Fibre Company, Inc., 310 Wheeler Street, Tonawanda, N.Y.

NOTHING *can equal Stainless Steel*

in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. For a reliable source of supply, United States Steel offers you the widest range of types, finishes and sizes.

UNITED STATES STEEL CORPORATION, PITTSBURGH
AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

USS

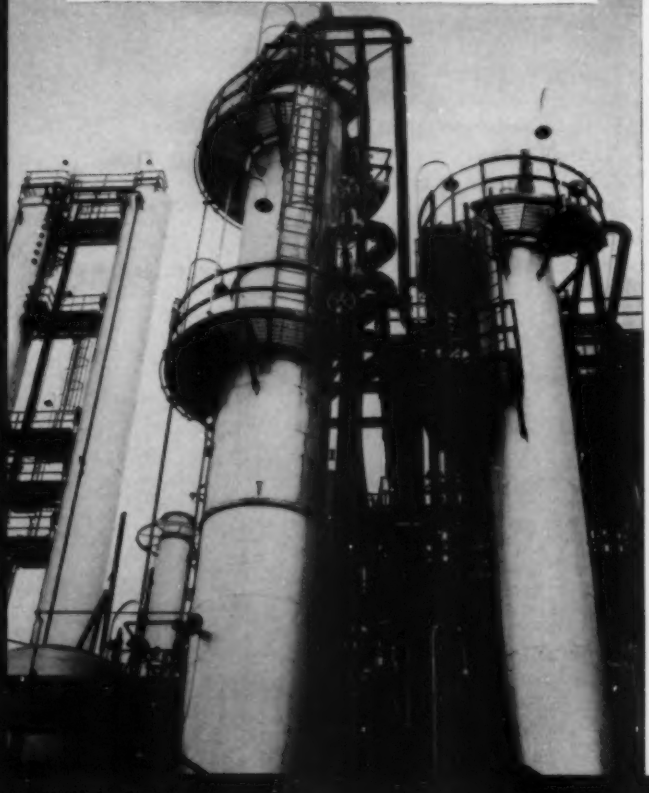
UNITED STATES STEEL

For Sanitation

Food juices are incredibly corrosive, so some restaurants have a lot of trouble in their cold storage rooms because the racks corrode and harbor bacteria. Eastern Steel Rack Company makes racks from Stainless Steel. They are easy to keep clean; and, for all practical purposes, they *never* wear out.

For Corrosion Resistance

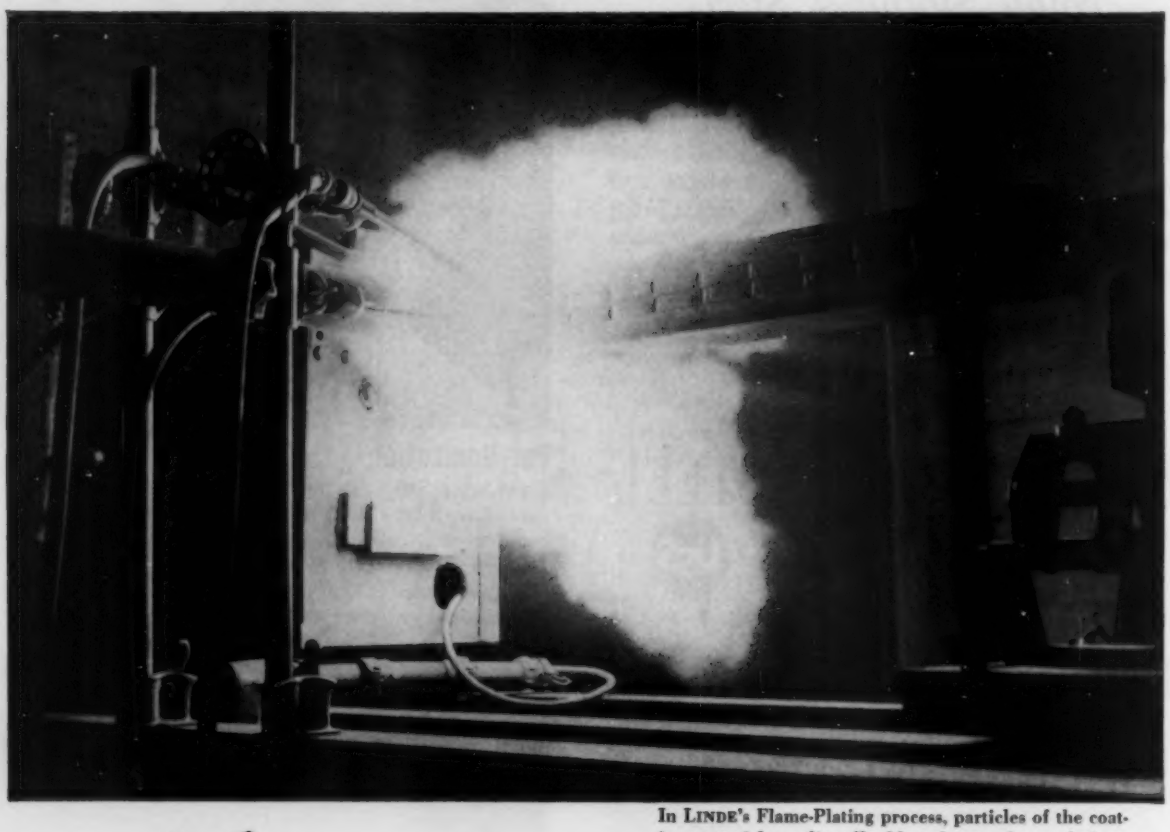
This petrochemical extract fractionator was originally made from carbon steel . . . but corrosion ate through the plates and put it out of service in *just two months.* They lined the tower with type 316 Stainless Steel. When examined, the tower had been in service 21 months, and the Stainless was still in good condition.



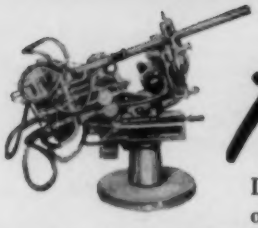
For Cleanliness

Hawthorne Paper Company, Kalamazoo, Mich., goes to extraordinary lengths to guard against color contamination. Old wooden tanks were thrown out and replaced with Stainless Steel. According to the men at Hawthorne, the Stainless has absolutely no contaminating effect, and it's easy to fabricate.

A LOW-POROSITY, WEAR-RESISTANT ALUMINUM OXIDE COATING



In LINDE's Flame-Plating process, particles of the coating material are literally *blasted* onto the workpiece.



Flame-Plating by Linde
Trade-Mark

LINDE's Flame-Plating method of coating metal surfaces now provides extra wear resistance for parts subject to extremely hard wear and high temperatures. This new high-purity aluminum oxide coating, blasted from the Flame-Plating gun, builds up on the workpiece in desired thicknesses from .002 to .040 inch. With a porosity of *less than 1 per cent*, the aluminum oxide coating can be used at temperatures up to 1750 degrees F.

The hardness of aluminum oxide coatings, Flame-Plated by LINDE, ranges from 1000 to 1200 VPN. Metallurgical properties of the base metal are not modified by the Flame-Plating process because the part being plated always remains at a temperature of 400° F. or below. The bond between coating and base metal is exceptionally strong with aluminum. Aluminum oxide coatings can be used in as-coated condition (approximately 120 microinches rms), or finished to better than 1 microinch rms.

Flame-Plated coatings of aluminum oxide provide resistance to wear, and to chemical action in high temperature applications. Applications are found in thrust bearings, pump plungers, thermocouple tubes, gas turbines, guided missiles, and other devices. Either aluminum oxide or tungsten carbide can be Flame-Plated on most metals. If you have a special wear problem, LINDE's Flame-Plating Department will gladly help you to reach a solution. Write to "Flame-Plating Department P-2."

LINDE AIR PRODUCTS COMPANY

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, New York

In Canada: Linde Air Products Company, Division of Union Carbide Canada Limited, Toronto

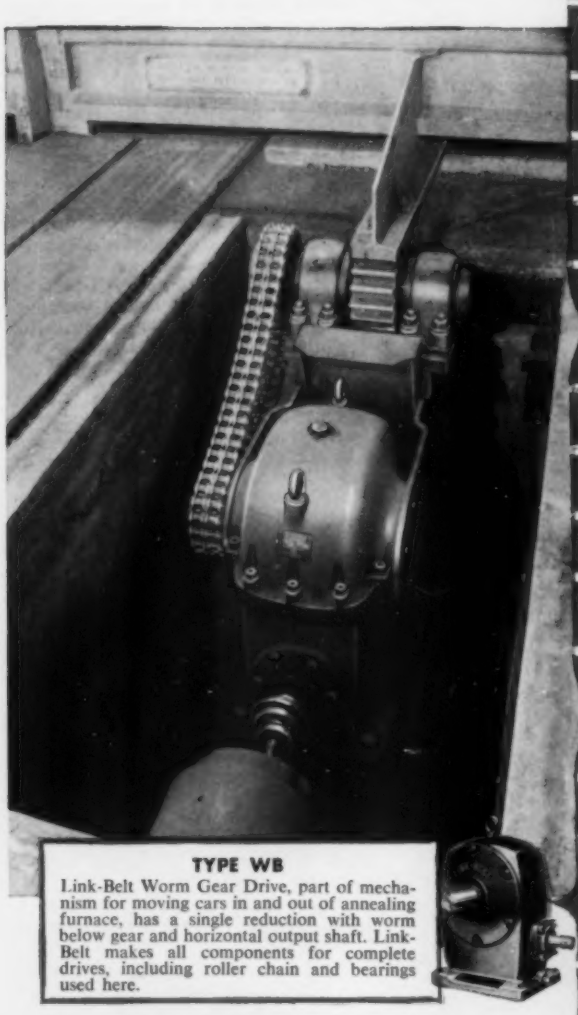
The term "Linde" is a registered trade-mark of Union Carbide and Carbon Corporation.

Flame-Plating by Linde

Arrange high-ratio speed reduction in least space from

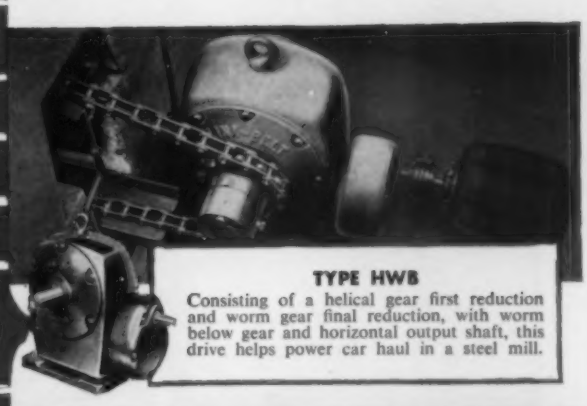
these 4 and 15 more

LINK-BELT Worm Gear Drives



TYPE WB

Link-Belt Worm Gear Drive, part of mechanism for moving cars in and out of annealing furnace, has a single reduction with worm below gear and horizontal output shaft. Link-Belt makes all components for complete drives, including roller chain and bearings used here.

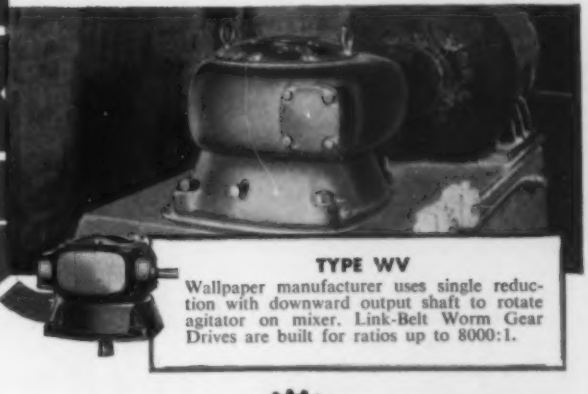


TYPE HWB

Consisting of a helical gear first reduction and worm gear final reduction, with worm below gear and horizontal output shaft, this drive helps power car haul in a steel mill.

TYPE DWV

This double-reduction Link-Belt Worm Gear Drive is available with output shaft extending either up or down. Its compactness is utilized to advantage on trolley conveyor caterpillar drive.



TYPE WV

Wallpaper manufacturer uses single reduction with downward output shaft to rotate agitator on mixer. Link-Belt Worm Gear Drives are built for ratios up to 8000:1.

ADD to basic compactness the application flexibility offered by 19 types — and you'll find the perfect mating of speed and need in the complete Link-Belt line of Worm Gear Drives. For selection guidance and full data, ask your nearest Link-Belt office for copy of 80-page Book 2324-A.

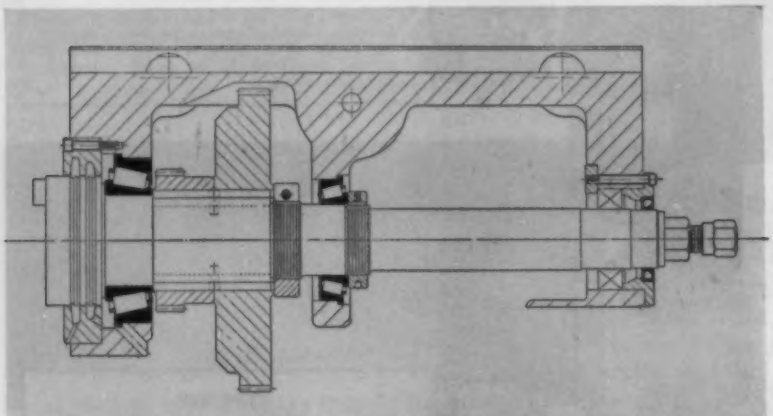
LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

LINK-BELT

ENCLOSED DRIVES

14,307

New! Completely redesigned milling machine switches spindle to TIMKEN® bearings



KEMPSMITH MACHINE COMPANY mounts the spindle of their new Kempsmith Master-Mill milling machine on Timken tapered roller bearings to hold spindle in rigid alignment.

THIS Kempsmith Master-Mill, made by Kempsmith Machine Company, is a brand new, improved model—designed to meet new demands for higher production, lower milling costs. Kempsmith switched to Timken® tapered roller bearings on the new Kempsmith Master-Mill to offer users their many advantages on the spindle, on the table leadscrew, on elevating pinion, and cross feed screw.

Kempsmith reports that Timken bearings are easier to install and adjust, have greater load capacity in small space, are much easier to preload.

Timken bearings hold the spindle in rigid alignment, meeting the requirement of "zero end play over a 24 to 1500 rpm speed range." Tapered construction lets Timken bearings take the radial and thrust loads encountered by a milling machine spindle, in any combination.

Timken bearings were specified, too, because of the heavy shock loads induced by the milling cutter—shocks further amplified by interrupted cuts. Rollers and races in Timken bearings are case-carburized, with tough, shock-resistant cores under hard wear-resistant surfaces. They'll *take* heavy shock loads! And Timken bearings give extra load-carrying capacity with their full line contact between rollers and races.

Geometrically designed for true rolling motion, Timken bearings are precision-manufactured, under rigid quality controls, to conform to their design. We even make our own steel, something no other American bearing maker does. Buying or building machines like this? Look for the trade-mark "TIMKEN" on every bearing! The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN TAPERED ROLLER BEARINGS ROLL THE LOAD

TRADE-MARK REG. U. S. PAT. OFF.

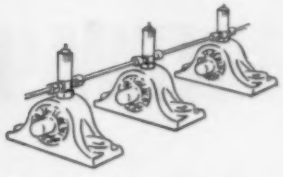
Design for

Automatic Lubrication From One Central Point

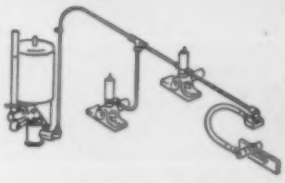
with an ALEMITE Accumatic® System

FASTER . . . FOOLPROOF . . . LESS COSTLY!

Replace grease cups or grease fittings with Accumatic fittings. (Available in same thread sizes as grease fittings, cups.)



Connect Accumatic fittings with copper tubing. (Alemite has tubing, clips and accessories for easy installation.)



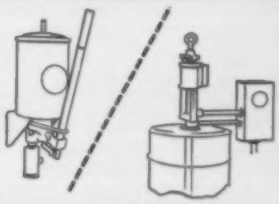
Connect sliding, rotary or oscillating parts into tubing system. (Flexible hose and swivels for moving parts.)

Type 1 Accumatic Valves

For fluid oil or light grease. In range of sizes, delivering from .005 to .100 cu. in. of lubricant. Various shapes: Tees, straight-thru, inserts, angles. Spring pressure provides gradual feed. Adjustable or fixed output. System serves up to 400 bearings. Manual or automatic operation available.

Factory-tested—field-proved!

Grueling field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles—equal to *122 years of twice-a-day service!*



Provide central pump to supply lubricant to system. (Ordinary hand pump or fully automatic barrel pump.)

ALEMITE ACCUMATIC ADVANTAGES!

- Prevents application of wrong lubricant.
- Seals completely against damaging dirt, grit and water.
- No parts are neglected—lubricates inaccessible and dangerous bearings at regular intervals.
- Eliminates product spoilage due to over-lubrication.
- Eliminates point-by-point lubrication methods—services all bearings in one operation.
- Delivers exact amount of lubricant to bearing.

FREE! Alemite Accumatic Catalog

Alemite, Dept. T-27
1850 Diversey Parkway, Chicago 14, Illinois
Please send me my free copy of the complete Accumatic Catalog.

Name .....

Company .....

Address .....

City ..... Zone ..... State .....

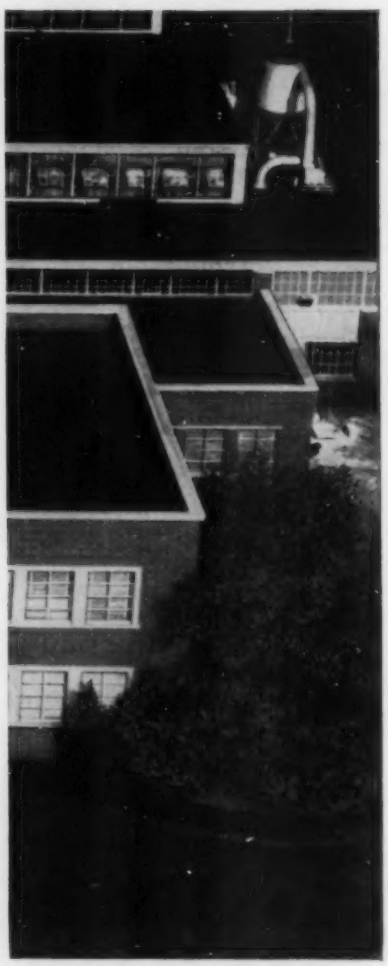
ALEMITE
REG U.S. PAT. OFF.

A Division of STEWART-WARNER CORPORATION

STEWART SW WARNER

Headquarters of the Metallurgical Products Department of General Electric Company, 11127 E. 8 Mile. Ave., Detroit 32, Michigan. Carbides, vacuum-melted alloys, and hevimet are made here. G-E permanent magnets and specialty resistors are manufactured in the Edmore, Mich., plant.

CAN LOOK FORWARD TO FROM ELECTRIC'S PRODUCTS DEPARTMENT



The new G-E Metallurgical Products Department is the successor to the Carboloy Department. Here's what this change will mean to you.

Since 1928, the General Electric trademark "Carboloy" has been identified with a brand of cemented carbide. First used solely as a cutting tool material because of their strength and toughness, carbides have more recently become one of the designer's most effective wear-proofing materials.

Carboloy® cemented carbides are manufactured by the new Metallurgical Products Department—successor to the Carboloy Department, which G-E organized to produce this metal for industry. But today carbides are just one of a broad range of products and materials this Department manufactures—many of which do not carry the famous Carboloy trademark.

These include G-E Alnico permanent magnets, thermistors, and Thyrite® varistors which have helped solve many basic design problems in the electrical and electronics industries. And G-E vacuum-melted alloys, and hevimet, which are now making important contributions to advanced aircraft, automotive, and atomic energy programs.

Thus, the new departmental name symbolizes the broadened scope of this Department's activities . . . a scope which will have far-reaching effects for design engineers in every phase of industry.

For General Electric – through its Metallurgical Products Department and the G-E Research Laboratory – is carrying on fundamental investigations which are extending the frontiers of metallurgy.

For example, the process which created G-E man-made diamonds may yield new structural and design materials which do not even exist in nature. And General Electric's work in powder metallurgy, metallic oxides, and semiconductors – which produced many of the products mentioned above – has a fascinating future all its own.

New products, and new methods of utilizing these products, are on their way. And when they are developed, they, too, will come to you from the new G-E Metallurgical Products Department.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Immediate Delivery...

on Mallory Silver Rivet Contacts

Mallory Silver Rivet Contacts are standardized in 70 stock types and sizes—which means you can count on immediate delivery for pilot run or production.

Mallory's standardization program was built on the results of an intensive study of thousands of silver rivet contact orders. From this survey, 70 basic types were evolved to fit the great majority of applications specified in these orders.

Availability from stock means time saved on orders. Standardization means a wide selection of catalog items, often providing an in-stock item for what might otherwise have been a specially tooled job with its associated higher cost and longer wait.

Dimensions, part numbers, ordering information and pricing data are included in the Mallory folder on silver rivet contacts. Before you place a specially tooled rivet order, why not check the Mallory list for a stock item—and tally up added cost savings on your next production run? Write—or ask the Mallory representative for your copy of Bulletin 3-15A.

IF ... your requirements are unusual, and do call for special contacts—Mallory engineers will be glad to assist in designing and specifying—Mallory production facilities are available for contacts or complete contact assemblies.

Expect more... get more from

P. R. MALLORY & CO. Inc.

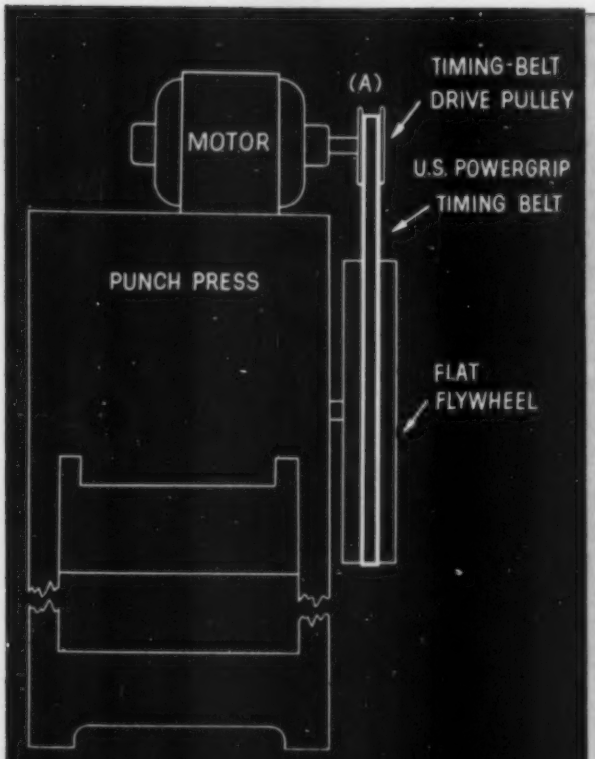
MALLORY

P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

Serving Industry with These Products:

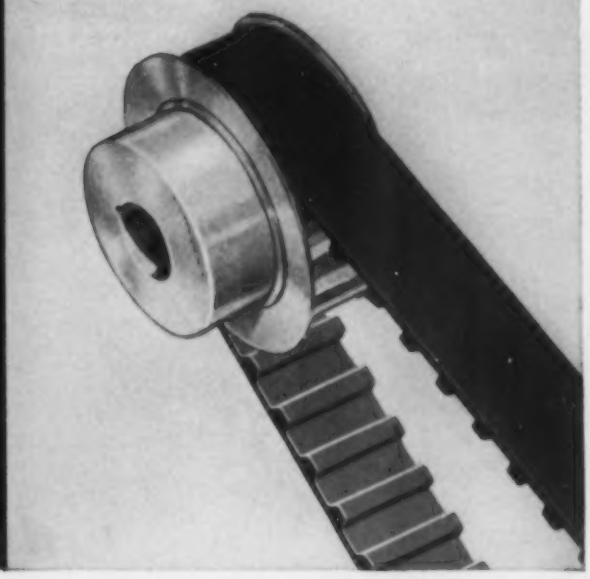
Electromechanical — Resistors • Switches • Tuning Devices • Vibrators
Electrochemical — Capacitors • Mercury and Zinc-Carbon Batteries
Metallurgical — Contacts • Special Metals • Welding Materials

PowerGrip "Timing" Belts



To eliminate severe belt slippage and consequent burning of belt (at point A) when 5 h.p. motor was started, the conventional pulley and belt drive from the motor shaft were replaced with a grooved pulley and a U.S. PowerGrip "Timing" Belt driving the flat flywheel. The positive engagement of the "Timing" Belt eliminated slippage on the motor pulley completely. The slight remaining slippage is now dissipated over the much greater area of the flywheel. Result: Flywheel gets up to speed *without burning the belt*, thereby reducing maintenance and downtime costs.

How a plant engineer made this press deliver a better punch



This is one more example of the U.S. PowerGrip "Timing"® Belt's ability to simplify and improve a power transmission unit . . . one of the reasons why the invention of this belt was recently awarded the Franklin Institute's Edward Longstreth Medal for "Invention of High Order."

Whether it's a plant conversion or original equipment design problem, U.S. PowerGrip "Timing" Belts offer the plant and design engineer all these advantages:

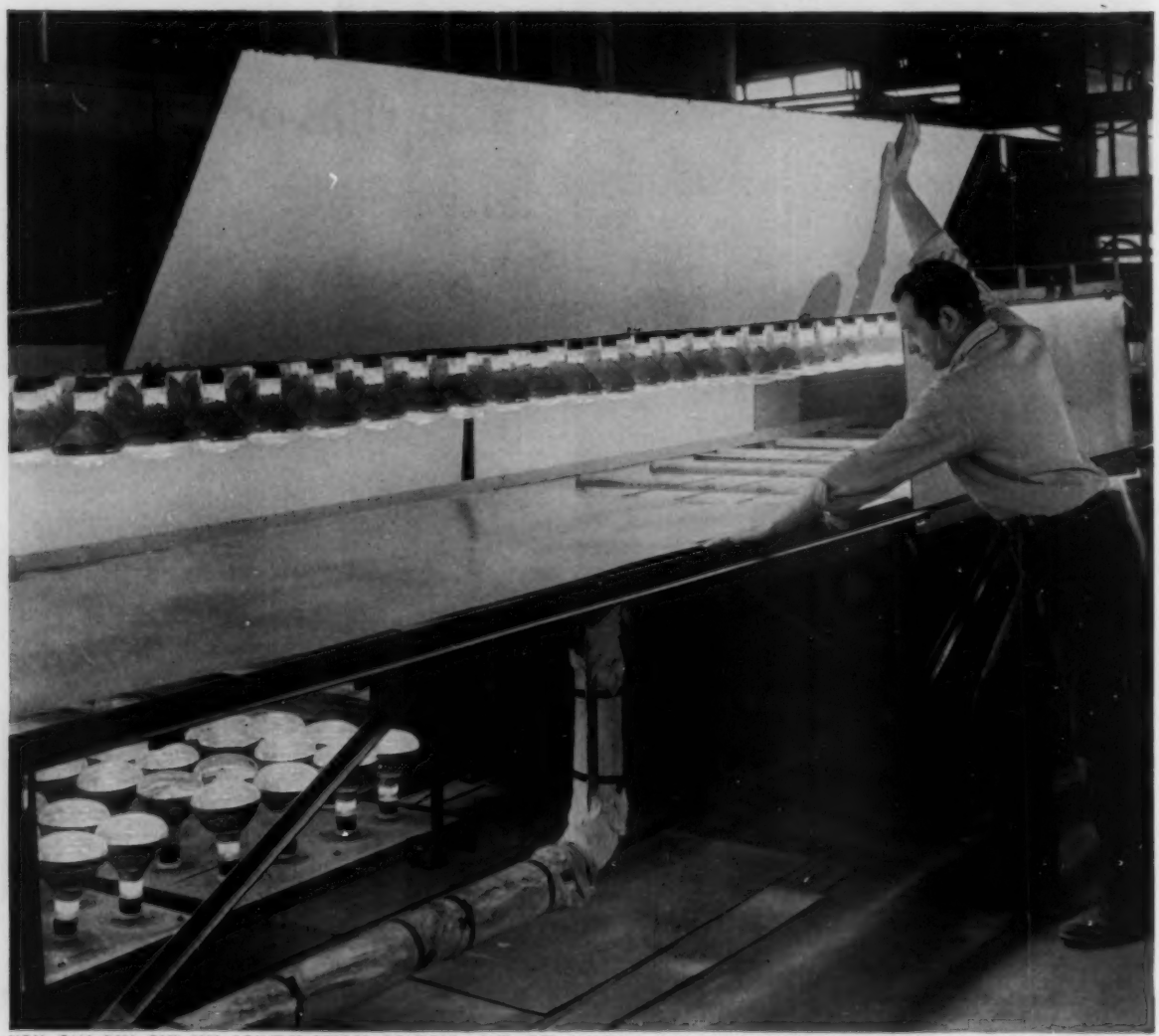
- *no slippage, no take-up—allows short centers, high ratios.*
- *absence of metal-to-metal contact—eliminates need for lubrication and housing devices.*
- *handles speeds up to 16,000 F.P.M. or so slow as to be imperceptible to the eye.*
- *close to 100% efficiency.*
- *imbedded with steel cables for high tensile strength.*
- *constant angular velocity.*

These belts—plus expert engineering service—are obtainable at "U.S." power transmission distributors, at any of the 28 "U.S." District Offices, or by writing us at Rockefeller Center, New York 20, N. Y.

Mechanical Goods Division

United States Rubber

Speed high-strength sandwich bonding by predrying 3M adhesive EC-1357



YOU CAN DRY OUT THE SOLVENT BEFORE BONDING—AND GET MAXIMUM IMMEDIATE STRENGTH FAST—WITH 3M ADHESIVE EC-1357.

Here's new speed in making light, rugged sandwich panels for non-load-bearing uses!

It's EC-1357. This specially formulated, fast adhesive from the laboratories of 3M gives you high bond strength *immediately!* With infrared ovens, you can dry the solvent out of EC-1357 before bonding. Heat absorption is fast, due to EC-1357's dark color. You eliminate unnecessary drying and storage time.

You need no clamps or heated presses, just cold press or nip roller. What's more, this cold bond continues to cure at room temperatures—gains added strength with age.

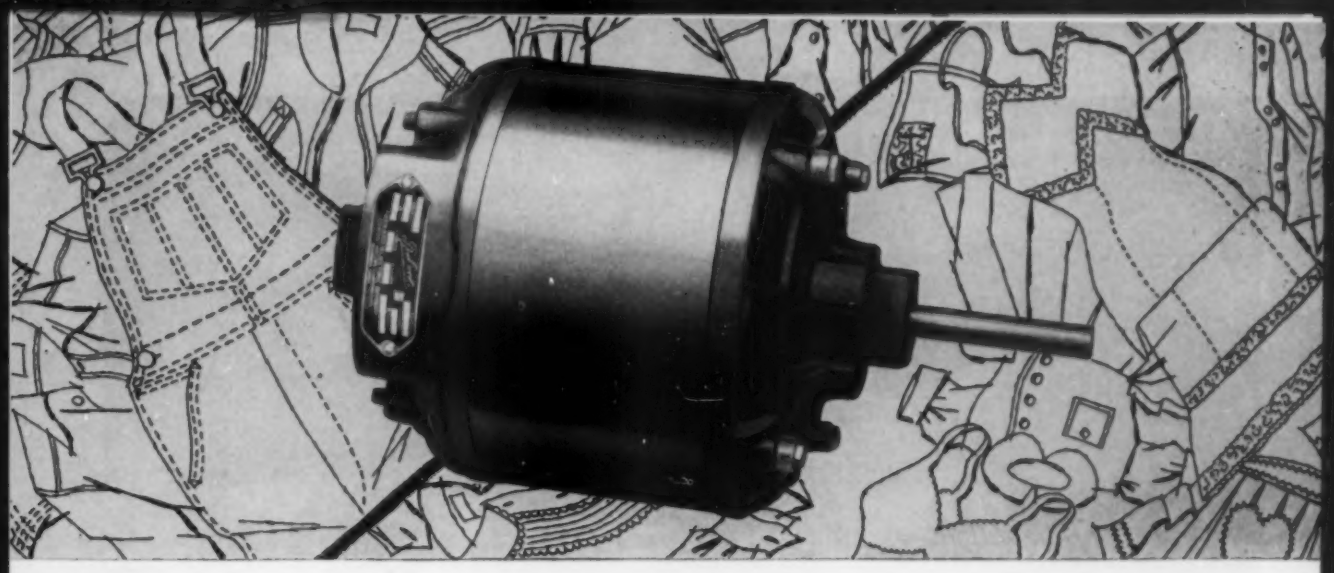
On metal or paper honeycomb cores, EC-1357 builds up a fillet for bigger bonding area and strength. Use EC-1357 with glass foam cores, too.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU! Consult 3M Research, contact your 3M Field Engineer or write on your company letterhead for information and free literature to: 3M, Dept. 72, 417 Piquette Ave., Detroit 2, Mich.

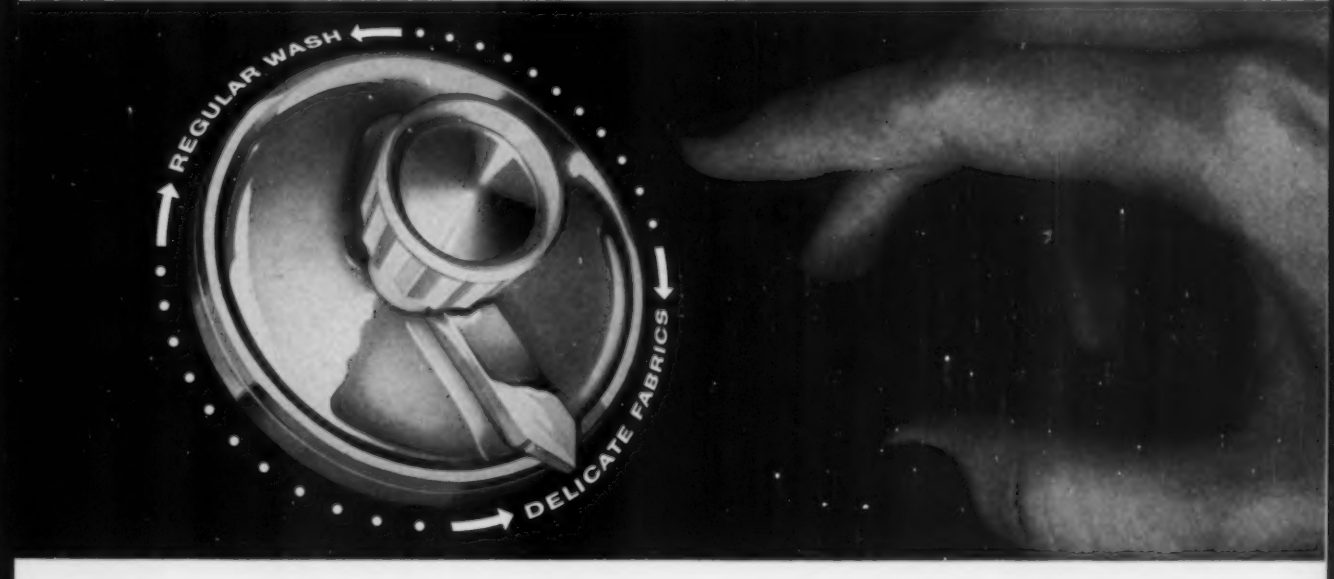
PRODUCT OF 3M COMPANY RESEARCH

MINNESOTA MINING AND MANUFACTURING COMPANY · ADHESIVES AND COATINGS DIVISION

417 PIQUETTE AVE., DETROIT 2, MICH. • GENERAL SALES OFFICES: ST. PAUL 6, MINN. • EXPORT: 99 PARK AVE., N.Y. 16, N.Y. • CANADA: P.O. BOX 757, LONDON, ONT.



PACKARD ELECTRIC / *NEW... custom-tailored washing machine motor*



FHP MOTORS / *Provides power for two washing speeds... electrically!*

It's an old idea based on need. Make the agitator speed variable. Then, both light and heavy clothes could be thoroughly washed without harming fabrics.

There were no two-speed appliance motors available with enough power at both speeds. Mechanical means, such as gears, belts and pulleys, clutches, etc., cost too much, took up too much space, made too much noise and caused too many maintenance problems.

A Packard Electric motor engineering team was first to solve the problem with a compact, two-speed unit that had just the amount of speed, power and torque required. And washing machine manufacturers who worked out the solution with Packard Electric engineers have had a big competitive advantage ever since.

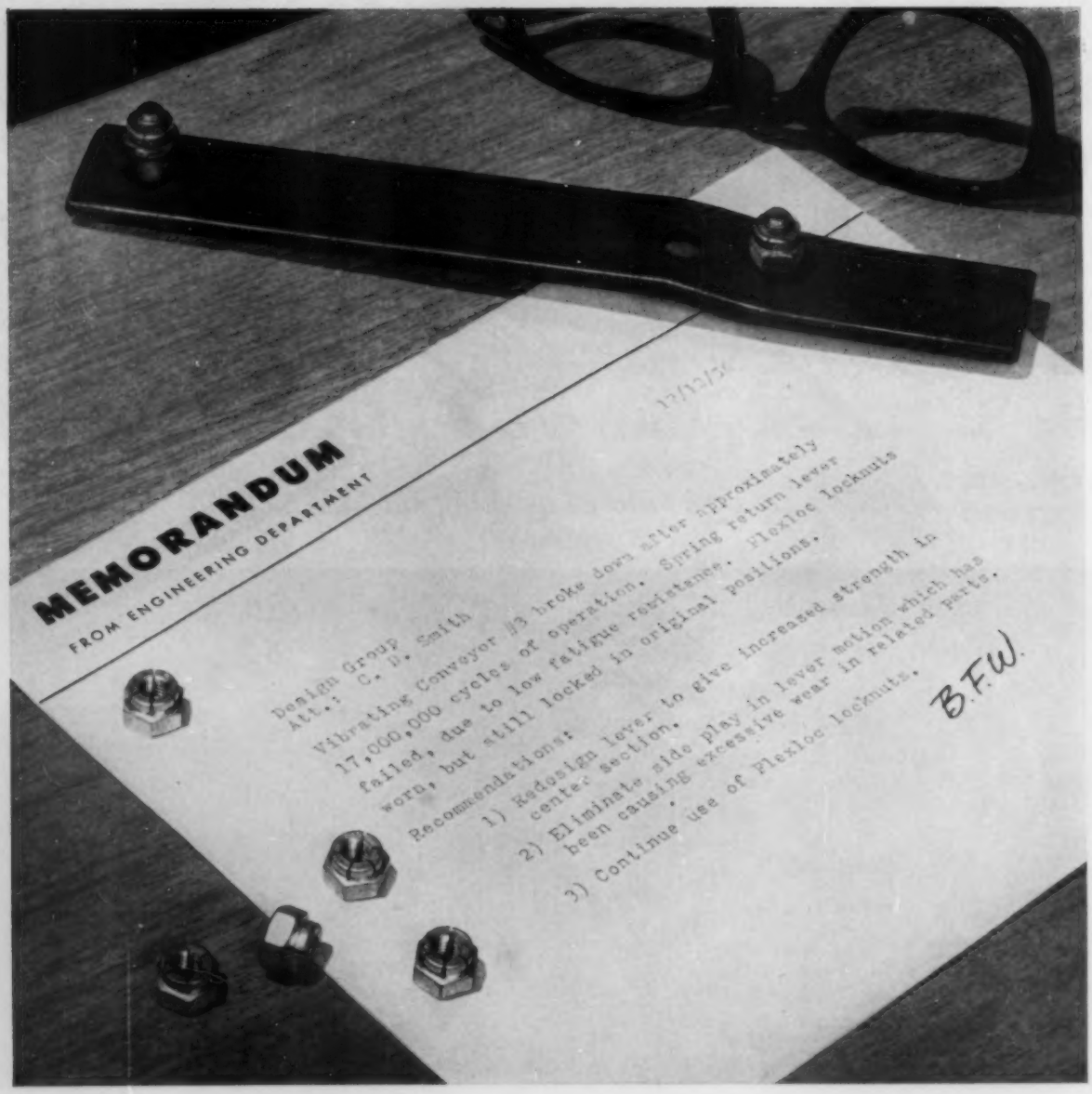
What's more, there are further savings in assembly when you buy Packard. That's because Packard will deliver a motor complete with special mountings and accessories to simplify your assembly procedures.

Packard Electric research and engineering teams have a long record of accomplishment in the custom-built motor field. And, even now, new ideas are on the boards to help our customers produce better, lower priced products for the appliances of tomorrow.

Packard Electric

Warren, Ohio GM GENERAL MOTORS

Division of General Motors


MEMORANDUM
FROM ENGINEERING DEPARTMENT
Design Group
Att.: C. D. Smith
Vibrating Conveyor #3 broke down after approximately
17,000,000 cycles of operation. Spring return lever
failed, due to low fatigue resistance. Flexloc locknuts
were, but still locked in original positions.
Recommendations:
1) Redesign lever to give increased strength in
center section.
2) Eliminate side play in lever motion which has
been causing excessive wear in related parts.
3) Continue use of Flexloc locknuts.
B.F.W.

Why designers specify FLEXLOC self-locking nuts

Where products must be tough . . . must stand up under vibration, shock and abuse . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts as fasteners.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting spring tension in the flexible locking collars. And they are reusable: rough screw threads, repeated removal and replacement, frequent adjustments will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes and materials, to meet the most critical locknut requirements. Your authorized industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

FLEXLOC® LOCKNUT DIVISION

STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA

STAINLESS STEEL MAKES THE DIFFERENCE

...its effect on modern styling

Clean lines. A crisp, new look. More functional. Lasting beauty. These are some of the effects modern designers gain with stainless steel—why they use more and more stainless steel every year in cars as well as appliances, housewares, furniture and houses.

To marketers, stainless steel combines the smart selling values of beauty and easy maintenance with the hard selling values of superior corrosion resistance, durability and toughness.

Stainless steel is available in countless work-saving standard shapes. It's readily machined, formed, joined, or cast.

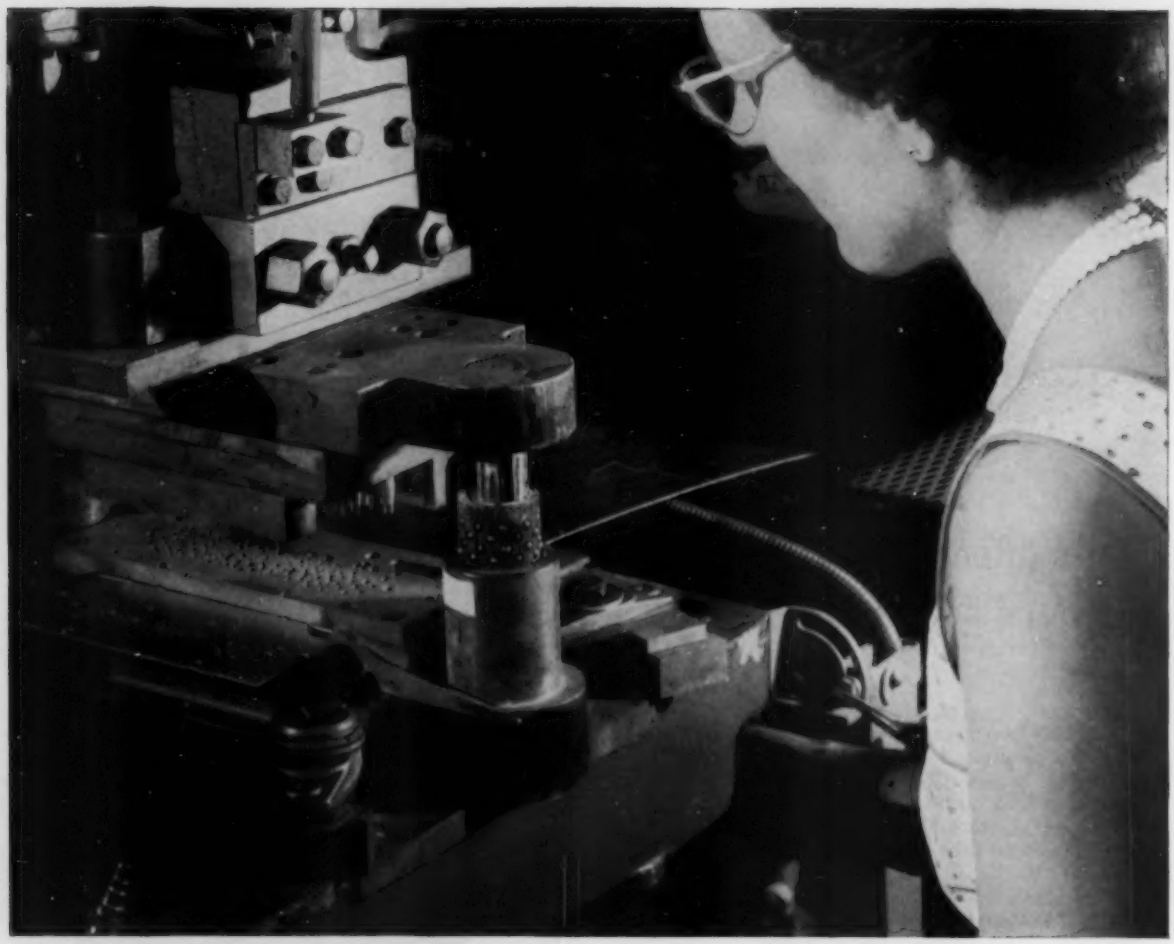
For more facts about stainless steel and the contribution it can make to your product or marketing problems, see your stainless steel supplier or write ELECTROMET—leading producer of more than 100 alloys for the metal industries, including chromium and manganese used for making stainless steels.

ELECTRO METALLURGICAL COMPANY
A Division of
Union Carbide and Carbon Corporation
30 E. 42nd Street UCC New York 17, N.Y.

METALS DO MORE ALL THE TIME ...THANKS TO ALLOYS

Electromet
Trade-Mark
FERRO-ALLOYS AND METALS

Stainless steel styling... first to catch the eye and quickest to capture the heart of the consumer. It combines beauty with hardness and strength to resist denting and scratching—and rust is never a problem.



New copper-clad **MICARTA**®
is easy to cold punch—no cracking, no chipping!

All holes in new H-3032 copper-clad MICARTA can be cold punched right on the assembly line in one operation, and there's no cracking, breaking or chipping. That is one of the reasons why this new laminate cuts costs and production time of printed circuits.

In addition, copper-clad MICARTA speeds up soldering, without the normal accompaniment of an increase in rejects and missed connections.

High bond strength — from 10 to 13 pounds versus an industry standard of six pounds — is retained even after heating and cooling are repeated many times, due to a new adhesive process.

If you have a circuit assembly problem, copper-clad MICARTA may be the answer. For further information and for technical data, write to Westinghouse Electric Corporation, MICARTA Division, Hampton, South Carolina. J-06626

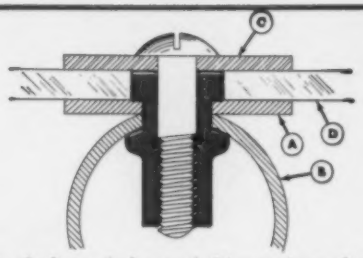
CAN BE DIP SOLDERED! MICARTA will not blister — even when dip soldered for 10 seconds at 500° F. A special adhesive actually increases adhesive strength during soldering.

YOU CAN BE SURE...IF IT'S Westinghouse

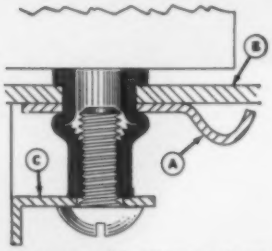
B.F. Goodrich Rivnut

cuts fastening time, saves money by doing two jobs in one operation!

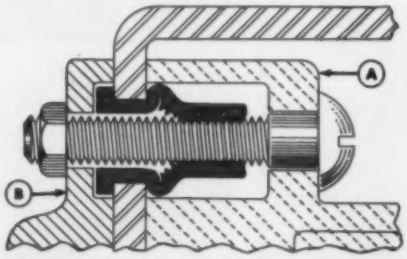
Do you have dual fastening problems like these?



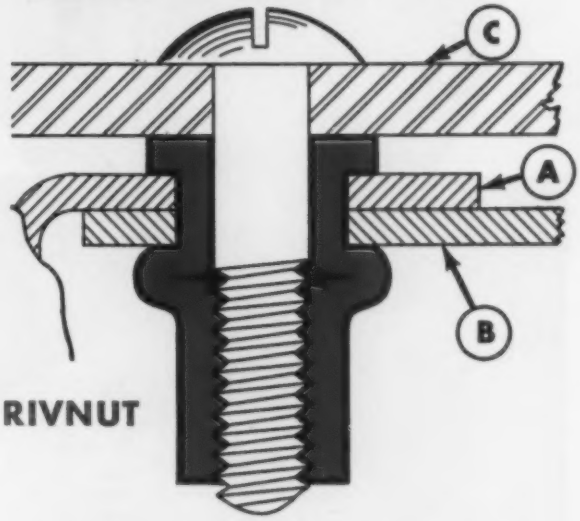
In airplane window seal, Rivnut rivets plate (A) to center post (B), provides nut plate to hold clamp strip (C). Rivnut head serves as spacer for transparent plastic sheets (D). Result: a neat, weather-tight seal!



In vaporizer assembly, Rivnut rivets upper flange (A) to casing (B), makes firm, accurate nut plate for attachment to lower flange (C). Rivnut eliminates reinforcing plate. Result: less assembly time, fewer parts, better product.



Rivnut provides 6-thread nut plate for attachment from either end—or *both*. In spotlight assembly, Rivnut replaces awkward welded stud for attaching socket (A). Plug base (B) is attached on other side. Result: fewer operations, lower assembly cost.



B. F. GOODRICH RIVNUTS cut costs and speed assembly because they rivet two parts together, make a firm, accurate nut plate for a third. And they do both jobs in one quick operation! Rivnuts can be installed from one side, take an attachment bolt from either end. They eliminate welding, tapping, clinching.

In the transformer assembly above, one worker fastens the metal cover (A) to the Glastic* sheet (B) with Rivnuts in seconds. Rivnuts then serve as mounting lugs for attaching completed transformer to mounting plate (C).

B. F. Goodrich Rivnuts have speeded up thousands of fastening jobs—can do the same for you.

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten WITH and TO. Explains construction, simplicity of installation. Get your free copy today by writing to: B. F. Goodrich Rivnuts, Dept. PE-27, Akron, Ohio.

*T. M. Reg. The Glastic Corp.

B.F.Goodrich

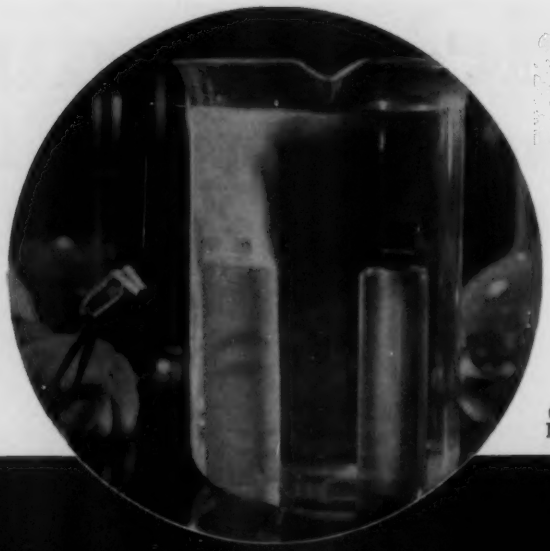
AVIATION PRODUCTS

a division of The B. F. Goodrich Company, Akron, Ohio

For today's problem

HAVE

Glass-

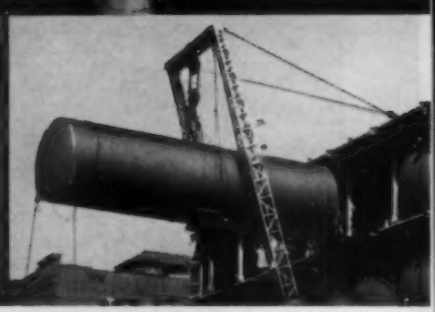


(Left) Comparative test by acid. (Below) Physical inspection of glass-lined tanks.

Here's Proof

of performance by the world's largest manufacturer of glass-protected steel products...for home, farm and industry

PERMAGLAS water heaters . . . set new standards of life expectancy in tank linings.



PERMAGLAS beer storage tanks . . . guard product flavor, purity and uniformity.

products, and tomorrow's product problems

YOU CONSIDERED

protected steel?

Glass coating may be the answer to improving your product's chemical and physical properties — whether that product is the size of a 2-penny nail or a 25,000 gallon storage tank!

Here are the properties

Chemical

In order to create the custom-glasses that today protect steel against various kinds of chemical action — A. O. Smith developed and tested more than 3000 glass formulations.

A. O. Smith can protect steel with glass . . . to withstand all inorganic acids except hydrofluoric — with corrosion-resistance actually improving as acid concentration is increased. No organic acid has yet been found that will break down A. O. Smith's specially developed glass formulations. And even though the silica element of glass is soluble in alkali—A. O. Smith can produce glass coatings to stand off alkali conditions up to pH of 12 at boiling temperature.

The highly corrosive characteristics of water fail to faze A. O. Smith glass coatings . . . proved in actual service by more than 3,000,000 home water heaters.

Physical

A. O. Smith glass coatings provide a fusion bond that is both chemical and mechanical — to 10,000 psi. The glass cannot be separated from the steel until the yield point of the metal has been exceeded. Also, special coating techniques promote high dielectric strength . . . outstanding non-stick and anti-abrasive qualities.

Up to now 500° F. is peak operating temperature for chemical-resistant glasses, but A. O. Smith has successfully developed ceramic formulations for protecting base metals at far higher temperatures. For other types of service, ceramic coatings can protect carbon steels at up to 1250° F. . . . stainless steels at up to 1500° F.

NOW AVAILABLE FOR YOU...
the research and production facilities of A. O. Smith. Write for full information on a specific problem, or ask for free booklet, "THE STORY OF GLASS-PROTECTED STEEL."

Through research ...a better way

A.O.Smith
CORPORATION
MILWAUKEE 1, WISCONSIN
12 plants in New Jersey, Pennsylvania, Ohio, Illinois, Wisconsin, Texas and California
International Division: Milwaukee 1, Wisconsin

HARVESTORES for farm feed processing . . . *Permaglas* mechanized storage structures, handling industrial bulk materials, turn losses to profits.

PERMAGLAS smokestacks . . . answer industry's need for longer smokestack life . . . economically.

GLASCOTE (subsidiary) products for severest chemical processing service . . . defeat corrosion and contamination.

PERMAGLAS home heating and cooling . . . ceramic-coated heat exchangers prevent oxidation and condensate corrosion.

Dempster-Dumpster—a truck-mounted fork lift designed to handle trash and other bulk materials, shown in dumping position. INSET: "Dacron" is the reinforcement in the V-belts on the 13-inch, 2-groove drive—increasing delivered horsepower, efficiency of hydraulic pump.

How the Dempster-Dumpster's V-belt drive efficiency was increased by premium V-belts reinforced with DACRON

REG. U.S. PAT. OFF.

The lifting and steering power of the Dempster-Dumpster generates from a single hydraulic pump driven by V-belts. To insure dependable, slip-free operation and positive starting at this important spot, Dempster Brothers, Inc., switched to premium V-belts reinforced with Du Pont "Dacron"* polyester fiber. During the six years since the change, the belts have been proving their superiority on hundreds of Dempster-Dumpsters in use throughout the country.

Slippage and stretching have been sharply reduced by the 40% greater strength of belts made with Du Pont "Dacron". Two premium V-belts now do the work formerly handled by three standard belts. The belts remain stable . . . deliver more horsepower from the pump. And the ability of these belts to withstand greater shock loading assures fewer replacements, more efficient, trouble-free operation.

In designing *your* next drive, investigate the advantages of premium V-belts made with "Dacron". They combine the unique properties of the "Dacron" yarn made by Du Pont and the highest skills of the leading V-belt manufacturers. For a list of manufacturers using "Dacron" in premium V-belts, write to E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Dept., Wilmington 98, Delaware. Premium V-belts shown in above photo were manufactured by the U.S. Rubber Company.

6 REASONS FOR USING PREMIUM V-BELTS REINFORCED WITH "DACRON"

- Transmit up to 40% more horsepower.
- Withstand greater shock loading.
- Longer flex life.
- Cut downtime.
- Low stretch.
- Require less maintenance.

***"Dacron"** in V-Belts* DU PONT

REG. U. S. PAT. OFF. REG. U.S. PAT. OFF.

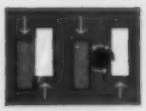
**"Dacron" is Du Pont's registered trademark for its polyester fiber.*

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

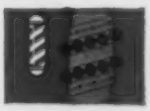
SAGINAW b/b SCREWS are guaranteed 90% EFFICIENT!

Require 4/5 LESS torque than Acme Screws for same linear output on Actuator and Positioner Applications! Saves space, weight!

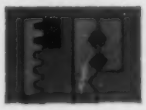
WHAT IT IS AND HOW IT WORKS



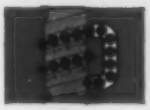
Let's start at the beginning, with the familiar principle that there's far less friction in *rolling* than in *sliding*. By applying this principle,



Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



the *Saginaw ball/bearing Screw* radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of *sliding*, mating surfaces *glide* on rolling steel balls.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

SIX DESIGN ADVANTAGES

1. Vital Power Savings. Permit much smaller motors with far less drain on electrical system, simpler circuitry.

2. Space/Weight Savings. Screws themselves are smaller, lighter; permit smaller motors and gear boxes; eliminate auxiliary equipment required by hydraulics.

3. Precise Positioning. Machine-ground type will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0006 in./ft. of travel.

4. Temperature Tolerance. Normal operating range from —75° to +275° F.; in selected materials, will function efficiently as high as +900° F.

5. Lubrication Latitude. If lube fails, will still function with remarkable efficiency. Units have been built and qualified for operation without lubrication.

6. Fail-Safe Performance. Far less vulnerable than hydraulics; Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance against failure.

SAGINAW b/b SPLINE

Utilizing the same basic *gliding ball* principle, Saginaw has developed the *Saginaw b/b Spline* which radically increases the efficiency of transmitting or restraining high torque loads.

Averages 40 times lower friction coefficient than sliding splines!

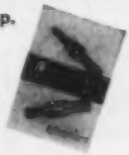
It can be fitted with integral gears, clutch dogs, bearing and sprocket seats, etc., for use with a wide variety of electrical units. Units have been built from 3 inches to 10 feet long—⅜ to 6 inches in diameter.

Available in custom machine-ground and stock rolled-thread types. Units have been built from 1½ inches to 39½ feet long—⅜ to 10 inches in diameter.

Saginaw ball bearing Screws & Splines

SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

SEND COUPON FOR NEW 1957 ENGINEERING DATA BOOK



Saginaw Steering Gear Division, General Motors Corp.
b/b Screw and Spline Operation
Dept. 6J, Saginaw, Michigan

Please send new engineering data book on Saginaw b/b Screws and Splines to:

NAME_____

COMPANY_____ TITLE_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

Alnico permanent magnets power the new Eriez Ferrotrap, visible above at left of the paper. Trap body and cover plate are Type 316 stainless chromium-nickel steel, non-magnetic and easy to clean.

How Alnico guards products and machines ...traps tramp metal continuously

This operator holds a collection of nails, paper clips and other ferrous contaminants. All were removed by the Eriez Ferrotrap from liquid caramel being pumped through a candy plant pipeline.

Keeping hot, viscous caramel free of tramp iron is an obviously difficult task. But a new Eriez unit, aptly named the Ferrotrap, does this sort of job with multiple rods or "fingers" containing Alnico permanent magnets.

No need for electromagnets, current and accessories, because at temperatures up to 850°F the powerful, life-time magnetic strength of a high nickel alloy . . . Alnico . . . assures positive trapping of iron particles. Even nuts, bolts, and the like.

Units that protect not only product purity, but also filters, mixers, pumps and other costly equipment are made practical by the powerful magnetic properties of Alnico, an aluminum-nickel-cobalt-iron alloy.

Nickel . . . an essential element in Alnico . . . improves hundreds of other alloys utilized in industry. So if you have a problem involving metals, consult us on the use of nickel or nickel alloys. But if you wish further information about the Ferrotrap, write Eriez Manufacturing Company, Erie 6, Pennsylvania.

INCO TRADE MARK **THE INTERNATIONAL NICKEL COMPANY, INC.** 67 Wall Street New York 5, N. Y.

PROVEN PERFORMANCE

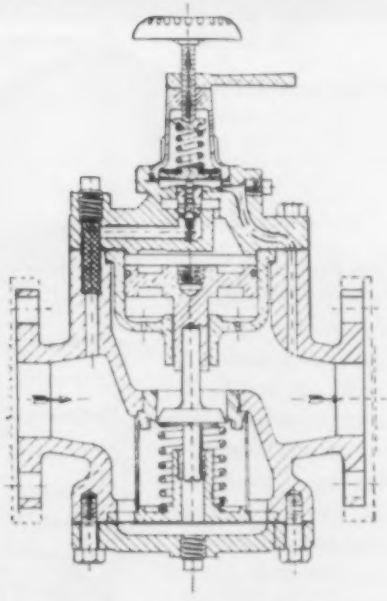
at A. E. STALEY Mfg. Co.

CASH STANDARD Type 44

Pressure Reducing and Regulating Valve for Steam Service

Sudden changes in the requirements for hot water in the employees' shower rooms at the **A. E. Staley** plant, Decatur, Ill., demand full capacity range operation of the regulating valve with precise control of downstream pressure.

In April of 1956, a CASH STANDARD Type 44 Steam Valve was installed in the line supplying steam to the heater. **Gerald Hammond**, instrument engineer at **Staley**, reports: "The CASH STANDARD Type 44 has given exceptionally good service—the kind of service we expect from all CASH STANDARD products. It has required no maintenance since installation eight months ago."



What's your control problem? Use this dependable steam valve.

Built in Pilot and Main Valve Strainers • Internal Pilot-Operated, Piston-Actuated • Single Seat • Highly Sensitive, Responsive to Smallest Changes in Reduced Pressure • Maximum Inlet Pressure 250 PSI @ 400°F. • Delivery Pressure 5-250 PSI • Available with External Sensing Line • Sizes 2", 2½", 3", 4".

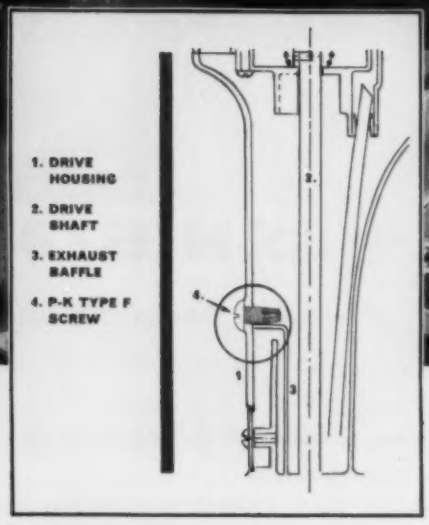
For an individual solution to your control problem, contact the CASH STANDARD specialist in your area, or write Dept. J.

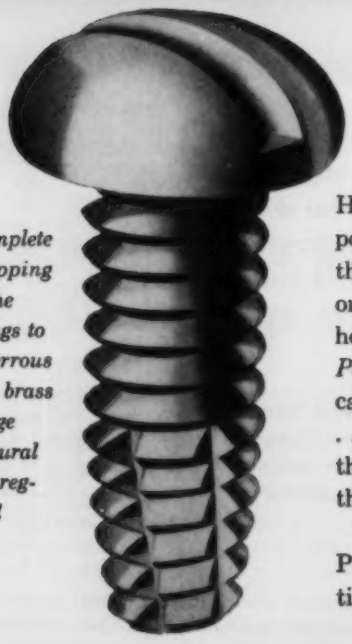
CASH CS STANDARD

A. W. Cash Co. and Its Subsidiary, Cash Standard Stacon Corp.
P. O. Box 551, Decatur, Ill.

PRESSURE, HYDRAULIC, TEMPERATURE, PROCESS AND COMBUSTION CONTROLS

how P-K® screws helped solve a design problem for EVINRUDE





Type F (one of a complete line of P-K Self-tapping Screws) used for the making of fastenings to ferrous and non-ferrous castings, bronze or brass forgings, heavy gage sheet metals, structural steel, plastics, impregnated plywood and other materials.

How do you keep a baffle from dropping down out of position? Designers of Evinrude outboard motors found the answer. No need for an expensive tapping operation or for a complicated stamping. Simply provide a cored hole in the casting, insert the stamping and then drive a *Parker-Kalon* Type F Screw through the hole in the die-cast housing. The screw acts as a retainer for the baffle . . . and because it is a *Parker-Kalon* Self-tapping Screw, there is no chance of its loosening during the operation of the motor. Yet it can be removed, if necessary.

This application is one example of the versatility of P-K Screws which designers can employ for various functions supplementary to fastening.

PARKER-KALON DIVISION, General American Transportation Corporation
Manufacturers of Self-tapping Screws, Socket Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws

PARKER-KALON® fasteners

Sold Everywhere Through Leading Industrial Distributors
Factory: Clifton, New Jersey—Warehouses: Chicago, Illinois—Los Angeles, California

solve many difficult control problems...use

OHMITE®

RHEOSTATS

with special features

Ohmite offers not only a line of *standard* rheostats but also rheostats with a wide variety of *special features*. Illustrated are only a few. All have the distinctive Ohmite design features: smoothly gliding metal-graphite brush; all-ceramic construction; insulated shaft and mounting; windings permanently locked in place by vitreous enamel. You will find the special rheostat feature you need in the dependable Ohmite line.

BUSHINGS FOR SPECIAL THICKNESS

Extra-long bushings and shafts for panels up to 2″ in thickness. Seven bushing lengths.

SCREW DRIVER SLOT SHAFT

Shaft ends slotted for operation with a screw driver where few adjustments are needed.

VENTILATED CAGES

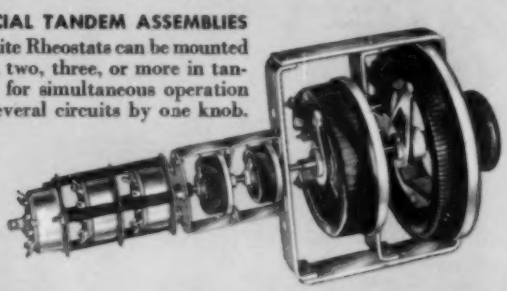
Prevents mechanical injury to rheostat or human contact with electrically "live" parts.

SENSITIVE SWITCH

Opens or closes circuit with minimum movement of control knob shaft. Extremely dependable long life switches.

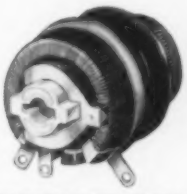
SPECIAL TANDEM ASSEMBLIES

Ohmite Rheostats can be mounted with two, three, or more in tandem for simultaneous operation of several circuits by one knob.



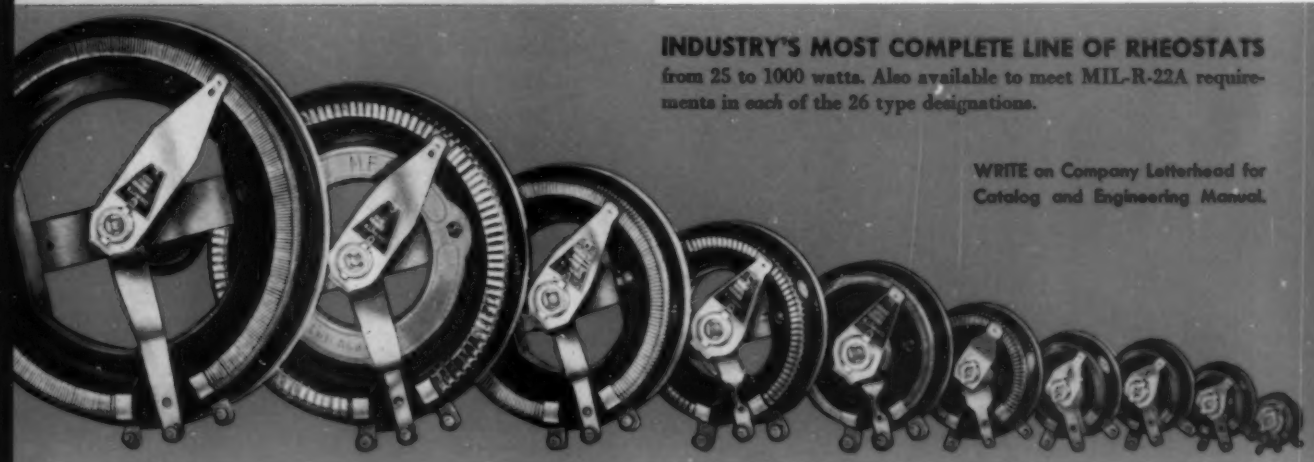
TOGGLE SWITCH

Is operated with a positive snap by the rheostat arm at either end position. Used for heavy-duty applications.



WITH OFF POSITION FEATURES

Opens circuit at high or low resistance position with *snap-action* (illus.); opens circuit at high resistance position with *dead lug* off position; or has *dead section* off position.



INDUSTRY'S MOST COMPLETE LINE OF RHEOSTATS

from 25 to 1000 watts. Also available to meet MIL-R-22A requirements in each of the 26 type designations.

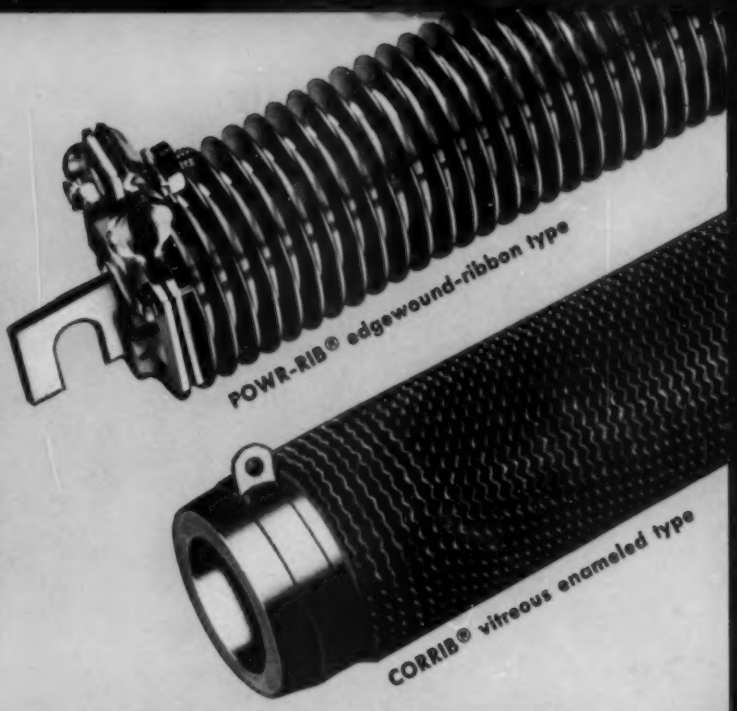
WRITE on Company Letterhead for Catalog and Engineering Manual.

RHEOSTATS • RESISTORS • RELAYS
TAP SWITCHES • TANTALUM CAPACITORS

BE RIGHT WITH OHMITE®

OHMITE MANUFACTURING COMPANY, 3611 Howard Street, Skokie, Illinois

specify OHMITE® *Power Type* **RESISTORS** for high current low resistance applications—



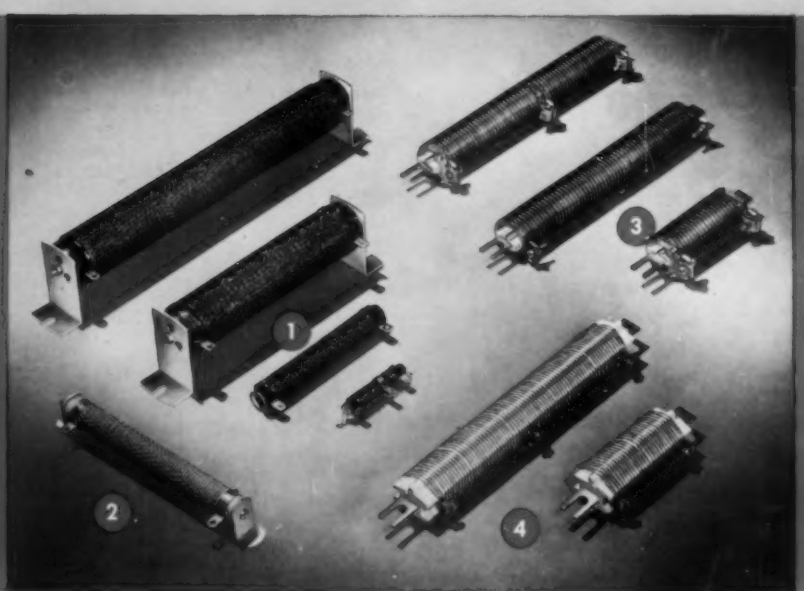
The Ohmite line of specialized CORRIB and POWR-RIB resistors solves your high-current, low-resistance problems. The four basic types of Ohmite units (shown below) handle a wide range of special power resistor needs. They are designed for continuous or intermittent duty and provide dependability for heavy-duty applications. Available in Fixed or Adjustable "DIVIDOHM®" Types.

IN STOCK—22 Corrib Resistance Values in 300 Watt Size (Core 8½" x 1⅛").

IN STOCK—26 Powr-Rib Resistance Values in 5 Section Size (17⅞" long).

Write for Bulletin 144

1. **CORRIB® vitreous-enameled corrugated-ribbon type**
   Fixed, tapped, and adjustable types in 25 sizes, 90 to 1500 watts. Resistances from .04 to 110 ohms.
2. **CORRIB® bare threaded tube type**
   For continuous or intermittent operation at higher than normal 375°C temperature rise. In two sizes, from 0.36 to 4.25 ohms.
3. **POWR-RIB® edgewound-ribbon type**
   Has ceramic core, sectionalized to resist shock. Four sizes. Values .043 to 1.6 ohms; 24 to 95 amps.
4. **POWR-RIB® round-wire type**
   Has sectionalized core similar to ribbon type. Four sizes. Values from .69 to 25 ohms; 5.1 to 18.4 amps.



Be Right with OHMITE®

OHMITE MANUFACTURING COMPANY, 3611 Howard Street, Skokie, Illinois (Suburb of Chicago)

RHEOSTATS
RESISTORS
RELAYS
TAP SWITCHES
TANTALUM CAPACITORS

FOR QUICK, POSITIVE LOCKING OF REMOVABLE SECTIONS

by Southco

LION No. 5 QUARTER-TURN FASTENER

Quick Release Feature Combined with High Strength-Weight Ratio

Superior Resistance to Vibration
Alignment Not Critical

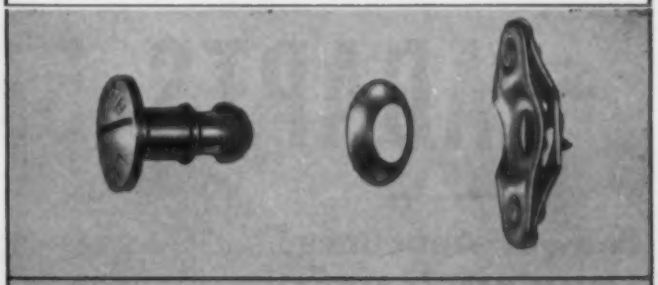
Ideally suited for fastening hinged or completely removable panels, Lion Quarter-Turn Fasteners are widely used by metal product manufacturers where frequent access for inspection or maintenance is required.

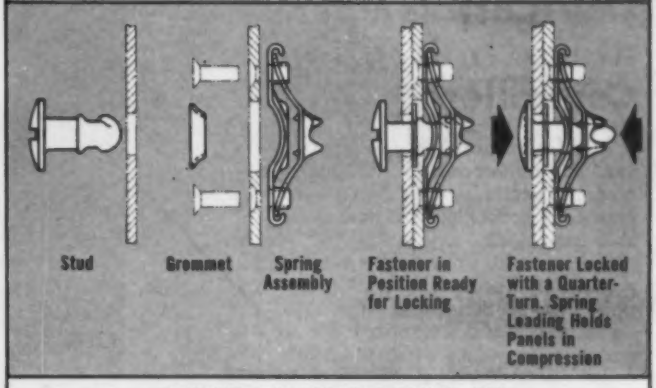
Locking and unlocking is accomplished without force in fractions of a second . . . one-quarter turn clockwise to lock tight . . . one-quarter turn counter-clockwise to unlock.

Lion Fasteners are safe, dependable, durable, economically installed, and provide long, trouble-free service.

Lion No. 5 Fasteners are available with flush head or oval head studs for screwdriver operation. Studs are also available with ring heads, wing heads, notched heads (for key operation), and knurled heads. Installation is simplified by a permissible float of .070 in all directions.

In addition to Lion No. 5 Fasteners, Lion No. H Fasteners are available for installation where extra high strength is required and Lion No. 2 Fasteners for application where strength is not an important factor.




Stud
Grommet
Spring Assembly
Fastener in Position Ready for Locking
Fastener Locked with a Quarter-Turn. Spring Loading Holds Panels in Compression

FULFILLS ALL REQUIREMENTS OF MILITARY SPECIFICATION MIL-F-5591A (ASG)

Locking torque, min.	5.0 lb. in.
Locking torque, max.	12.0 lb. in.
Unlocking torque, min.	5.0 lb. in.
Unlocking torque, max.	15.6 lb. in.
Initial tension, min.	35 lbs.
Rated tensile load	500 lbs.
Rated shear load	500 lbs.
Locking stop strength, min.	60 lb. in.

VIBRATION REQUIREMENTS

Frequency	3,600 CPM 100
Amplitude	1/16 in.
Load	175 lbs.
Endurance, min.	25,000 cycles
Lateral movement of Class A, Types I, II, and III Receptacle, min.	.062 in.

Lion Fasteners meet or exceed all of the specifications shown above.

Lion Catalog, containing complete specifications and installation procedure, sent free on request. Southco Div., South Chester Corporation, 236 Industrial Highway, Lester, Pa.

LION *Quarter-Turn* FASTENERS

SOUTHCO FASTENERS
LION

© 1956

SOUTHCO DIVISION
South Chester Corporation
236 Industrial Highway, Lester, Pa.

Please send me free Lion Catalog containing specifications and installation procedure.

NAME_____
COMPANY_____
ADDRESS_____
CITY_____ ZONE_____
STATE_____

NEW CONTROLLER LINE ADAPTS 576 WAYS

Fenwal Announces Low-Cost Temperature Indicating Controllers

ASHLAND, MASS. — Fenwal Inc., has announced here that tailor-made, accurate, low-cost temperature indicating controllers are now available from stock.

Tailor-mades from stock are made possible by the development of the new Fenwal Series 541 line. The Series 541 is a standardized line of matched temperature indicating controller parts which can be combined easily in 576 ways.

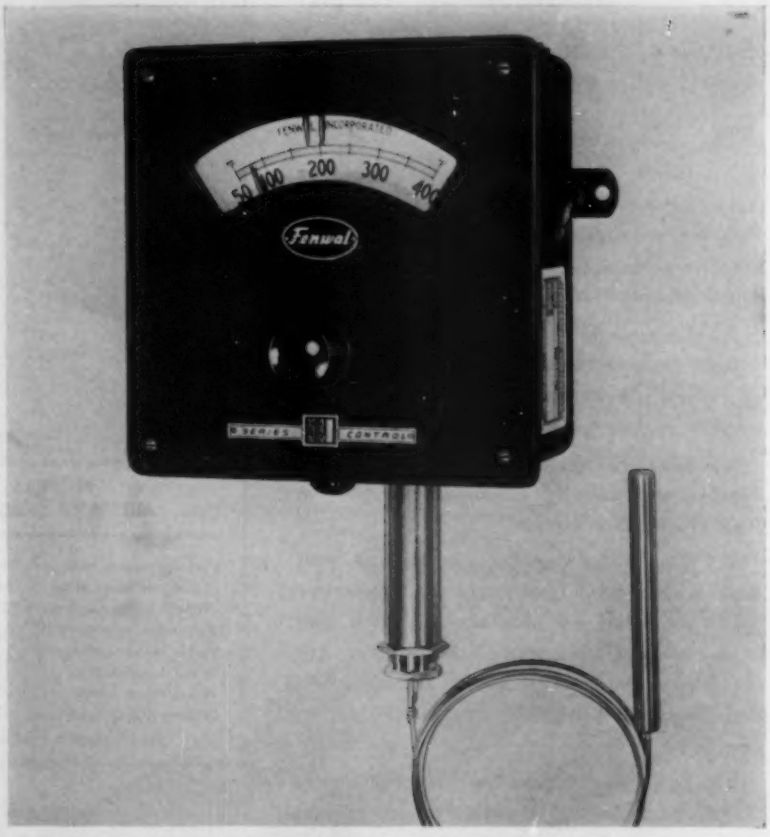
From these possible combinations come perfect solutions to countless temperature control problems. A prospective user lists the characteristics of the ideal temperature indicating controller for his particular operation, and Fenwal assembles an instrument with those characteristics from parts in stock.

No matter what combination is chosen, the result is a rugged, accurate, compact and easily maintained unit in a shock-proof, splash-proof, dust-proof housing. The housing is available in colors to match any equipment in which it may be installed.

Installation and calibration are so simple that instrument technicians and laboratory procedures are unnecessary. And, after installation, all normal temperature adjustments are external.

No matter what combination is chosen, the resulting instrument is accurate to within one per cent of scale. The accuracy is long lasting, with few moving parts and no internal gears. Simplicity of design brings the wear factor close to zero.

Series 541 offers single or double circuit control. There is a choice of four different long-life snap switches, with ratings up to 20 amps, 250 volts, A.C. These switches, singly or in combination, can provide a wide variety of operating characteristics.



One of Fenwal's new Series 541, bulb-and-capillary controllers. Photo shows dual circuit model which has two snap switches, each with a setpoint indicator, that actuate two separate circuits at the pre-set temperatures.

Three stainless steel bulb types are available at no increase in price to meet space or process requirements. Capillaries and bulbs are corrosion-proof. Capillaries are swivel-mounted to protect them from breakage.

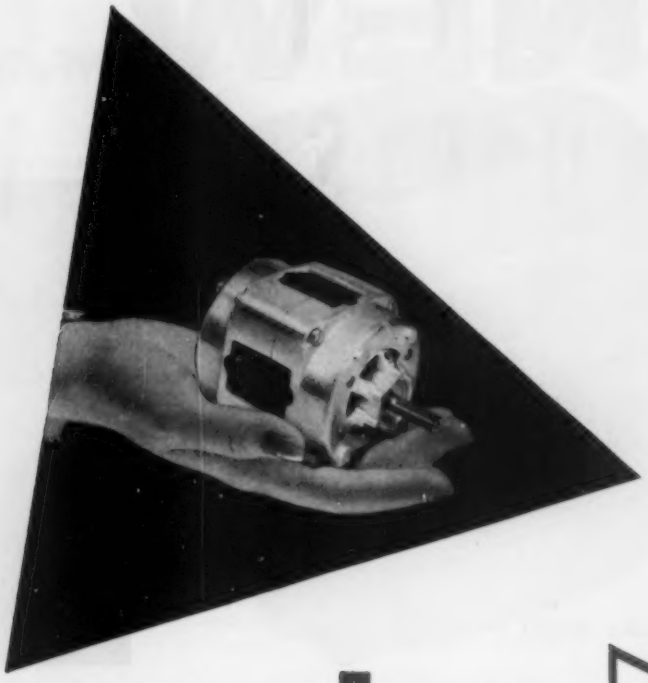
There is a choice of three temperature ranges: −150° to 200°F, 50° to 400°F, or 50° to 700°F, or their centigrade equivalents. Special ranges are available on request.

The control mechanism may be subjected to temperatures up to 150°F, and is ambient compensated from 50° to 150°F.

Write to Fenwal Incorporated, 22 Pleasant Street, Ashland, Mass. Describe the tailor-made temperature indicating controller that would fit your operation perfectly. Chances are excellent that the tailor-made can be yours — at savings never before possible.

Fenwal

CONTROLS TEMPERATURE ... *PRECISELY*



Announcing

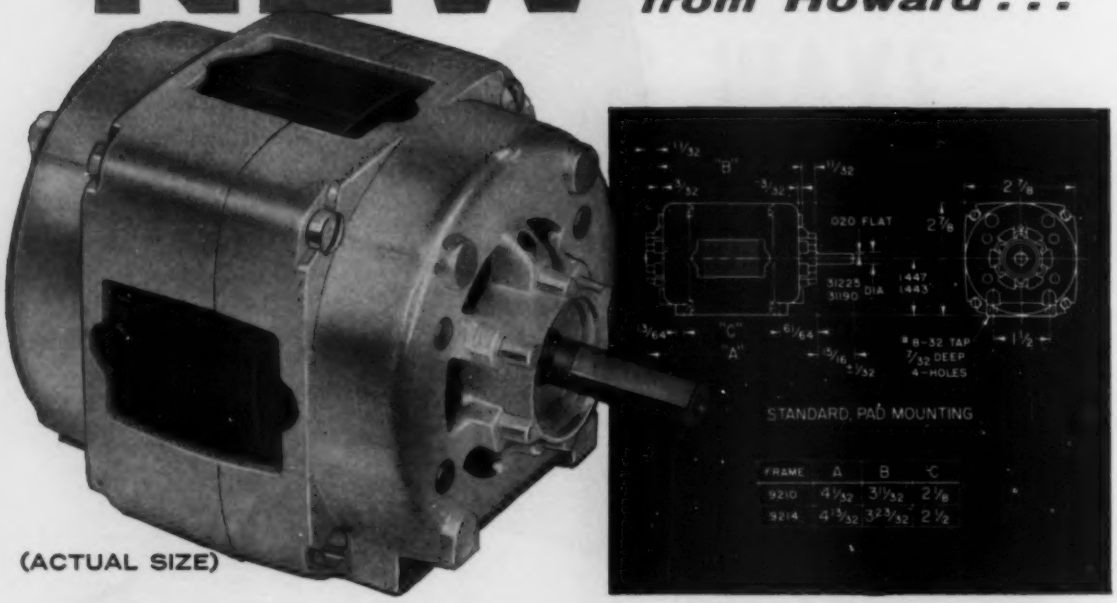
Turn the Page for Further Details

new
miniaturized
induction motor

HOWARD MODEL 9200
1/200 to 1/30 H.P.

Here's an outstanding new Induction Motor, available for fast delivery. Its performance ratings are exceptional, prices competitive and the applications are many. If you have a product using small Induction Motors, check the facts on the following two pages.

NEW *from Howard . . .*



Miniaturized Induction

HOWARD MODEL 9200 Permanent Split Capacitor, Single Phase, 50/60 Cycle Induction, Torque, Synchronous Type—Also available in two or three phase designs.

Now available from Howard Industries, Inc. is an exclusive Miniaturized Induction motor with *all* the features of an ultra modern power motor for use in tape recorders, communication equipment, office machines, turn table, movie projectors, air craft, instruments, electronic devices and many more applications

Special design of magnetic and electric circuits (24/20 slots), sinusoidally distributed windings, internal rotor slotting combined with unique mechanical features result in exceptionally quiet operation, low level magnetic hum, reduced external magnetic field, low temperature rise, minimum cogging and hunting.

This motor has been rated by engineers who know, as the finest small induction motor on the market. Performance ratings of these motors are outstanding, comparable to those of considerably larger frame sizes. For complete details, engineering drawings and samples, write, wire or phone HOWARD today.

PERFORMANCE COMPARISON
to conventional motor of the same output rating

RELUCTANCE SYNCHRONOUS SINGLE PHASE PERMANENT CAPACITOR TYPE

	Good Reluctance Motor	Howard SWC-9214 Motor
HP	1/75	1/75
Volt	115	115
C.P.S.	60	60
R.P.M.	1800	1800
Capacitor	2.5 MFD	2.5 MFD
Load Torque	7.5 oz. in.	7.5 oz. in.
Line Amps (input)	.37	.33
Line Watt (input)	36	34
Power Factor	85%	90%
Efficiency	27.7%	29.5%
Temp. Rise °C	36.5°C	26.3°C
Starting Torque	10 oz. in.	11 oz. in.
Pull-in Torque	9 oz. in.	11 oz. in.
Pull-out Torque	9.5 oz. in.	12 oz. in.

Unusual Power In a Small Frame Size . . .

CONSTRUCTION SPECIFICATIONS

General: Open, self ventilated, versatile mount construction. Laminations are stamped from high grade silicon electrical steel. The stator core is housed inside a rigid framework consisting of the two aluminum die cast end brackets telescoped into each other with both rabbets precision machined from bearing bores.

This type of construction eliminates the danger of bending out of shape of the stator structure which is possible in a conventional skeleton type motor.

Bearings: Motors can be supplied with porous bronze sleeve bearings of self aligning or rigid type. An adjustable thrust and end play device is provided with each motor for horizontal, vertical, or thrust loading.

With sleeve bearings, large felt oil reservoirs are provided. At request, motors can be supplied with permanently lubricated sealed or shielded ball bearings.

Rotors: Specially designed for uniform torque characteristics. The rotor bars are designed for maximum quietness and smoothness of operation.

A special design of reluctance synchronous rotor lamination allows for extra high starting torque and minimum noise and vibration level.

Hysteresis type rotors are constructed of heat treated cobalt steel shells of high hysteresis loss and magnetic retentivity.

Howard Model 9200 motors operate with practically non-detectable noise and vibration levels.

Cooling: A unique air circuit design provides an extremely efficient cooling of motor windings and the bearings. This results in extra long motor life requiring practically no attendance or maintenance.

Motor Model No. 9200

Windings: Heavy formex insulated magnet wire thoroughly impregnated and baked with a high grade oil and water resisting electrical varnish.

Mountings: Motor frame is designed to permit 6 types of mountings:

Rigid pad or base	Flange mounting
Recessed pad	Extended nut or thru bolt
Resilient ring (small and large size)	Face mounting

Frame Size: 2⅞ x 2⅞ with overall length of 4$\frac{1}{32}$ for 9210 frame and 4$\frac{13}{32}$ for 9214 frame.

Ratings: Single phase, 115, 50/60 cycle, permanent split capacitor, continuous duty, 40° C. rise and 2 & 3 phase 230 volts, 50 to 60 cycle.

Finish: The motor cases are normally not painted, but can be finished to meet special requirements.

Induction Type: (RWC 9210 & 9214) 2, 4, 6, & 8. Poles: HP Range: 1/300 to 1/30 HP.

Torque Motors: (RWH 9210 & 9214) 4 & 6 Pole. Torque Range: 5 to 12 Inch-Ounce of Stalled Torque Cogging of 6 pole motor + or − 2%.

Reluctance Synchronous: (SWC 9210 & 9214) 2 & 4 Pole.
HP Range: 1/250 to 1/50 HP.

Hysteresis Synchronous: (HWC 9210 & 9214) 2, 4, 6, & 8 Pole.
HP Range: 1/250 to 1/75 HP.

Other Howard motors: UNIVERSAL & D.C. 1/200 to ½ h.p. • SHADED POLE 1/2000 to ¼ h.p. INDUCTION 1/1400 to ½ h.p. • SERVO MOTORS • GEAR MORTORS • BLOWERS

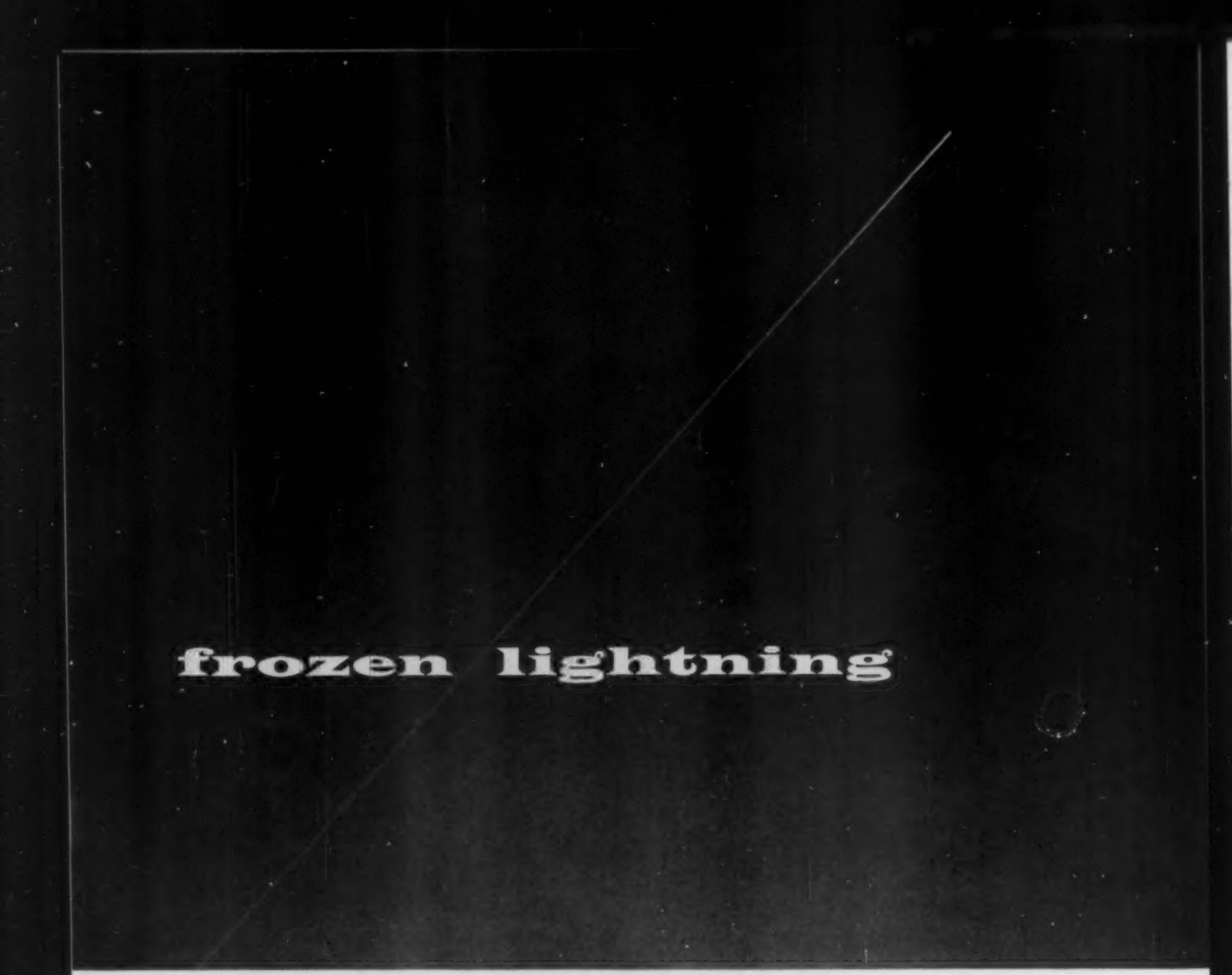
HOWARD

HOWARD INDUSTRIES, INC., 1750 STATE ST., RACINE, WIS. • TELETYPE: RAC 344

Sales Offices | *208 S. La Salle St., Chicago 4* | *942 S. La Brea Ave., Los Angeles 36* | *Room 4822, Empire State Bldg., New York 1*

Buy Defense Bonds

DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS



The Germans called the upper-atmosphere trails of their V-2 rockets "frozen lightning". When the Mach 4-5 aircraft now under development fly at 80-90,000 feet and higher, we'll be seeing frozen lightning in our own skies.

Not freezing but heating will be the real problem at these ultra high speeds. At 3000 mph, the skin and many structural components will be heated to over 1000°F, temperatures too high for alloys now used. Needed: materials strong up to 1200-1300°F for structural forgings and other stressed parts.

Engine builders, fastener manufacturers and forge shops are handling similar requirements right now, with Carpenter alloys. These alloys have gained an enviable reputation for uniform high quality, ability to meet tough specifications consistently, improved forgeability and exceptional cleanness. Forging tolerances can be tighter. Finishes are better. Rejects are far fewer.

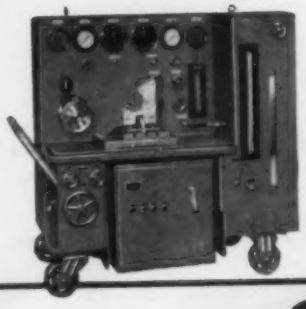
Design properties and fabrication instructions for these alloys are summarized in our new booklet, "Carpenter Alloys for Elevated Temperature Service". For your copy drop us a line on your Company letterhead. The Carpenter Steel Company, 117 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service

Pulpit type power unit provides full visibility, easy accessibility.

Compact power unit showing gasket-mounted valves.



Portable power unit for testing pumps.

Power unit with gasoline engine as prime mover.

Power unit for hydraulic control of electric furnace.

6837

Individually Designed to Meet *SPECIFIC* Needs

VICKERS

Custom Built

HYDRAULIC POWER UNITS

DEPENDABLE PERFORMANCE

IMPROVE AND SIMPLIFY DESIGN

REDUCE INSTALLATION COST AND TIME

EASIER SERVICING

BETTER APPEARANCE

Vickers engineers approach the design of a custom-built hydraulic power unit from the standpoint of the customer's INDIVIDUAL needs. The sole objective is to meet HIS requirements with the best hydraulic "package". This assures the most compact, efficient and convenient hydraulic equipment for the particular machine.

A Vickers Hydraulic Power Unit includes all necessary pumps, valves, intermediate piping, oil reservoir, motors, controls, etc., as well as all hydraulic accessories (oil filters, air cleaners, oil level gauges, fittings, etc.). Hydraulic connections can be grouped in a convenient manifold.

In addition to the advantages mentioned above, each Unit is pretested at the factory and ready for immediate operation. Vickers undivided responsibility for the entire hydraulic control system is also an important feature to both the machine builder and his customer. Write for Bulletin 52-45.

VICKERS INCORPORATED

DIVISION OF SPERRY RAND CORPORATION

ADMINISTRATIVE and ENGINEERING CENTER

Department 1454 • Detroit 32, Michigan

Application Engineering Offices:

ATLANTA • CHICAGO • CINCINNATI • CLEVELAND
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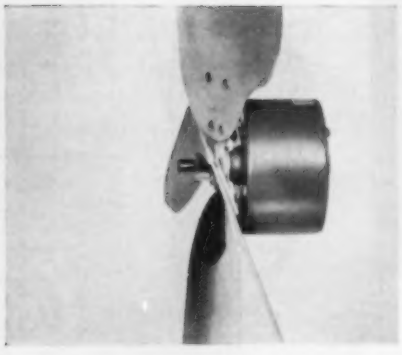
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

SMALLER DIAMETER and shorter length of this new motor make it possible to design compact, better looking, more salable products. Also speed installation, cut shipping costs and stocking space requirements.



MOUNTING CONVENIENCE—choice of either flush mounting with extended through-bolts (2, 3, or 4) or resilient mounting—helps solve design problems. Bearing construction permits all-angle operation.

PRECISION BRACKETS of heavy-gauge, drawn steel reduce motor length . . . provide quieter operation and longer life. Flat, circular area around through-bolts makes flush mounting possible—much easier.

NEW LUBRICATION SYSTEM with larger oil capacity circulates oil through filtering wicks . . . assures positive oil film between bearings and shaft plus quieter, cleaner, cooler—more economical—operation.

New motor goes on a diet to help streamline your products

More compact Westinghouse shaded-pole motor designed for today's modern air-moving equipment

Here, in a compact package smaller in diameter than conventional designs and no longer than a cigarette, Westinghouse has combined these benefits for you—lower costs, easier installation, minimum air-movement restriction, and longer, trouble-free operation.

Whatever your product—room air conditioners, ventilating fans, unit heaters and coolers, furnace blowers or the like—you will find new opportunities to cut costs, streamline your product and increase its salability with a new Westinghouse shaded-pole motor.

For more information on the new Westinghouse shaded-pole or permanent split-capacitor motors, contact your nearby Westinghouse sales office. Or, write Westinghouse Electric Corporation, Small Motor Division, P. O. Box 566, Lima, Ohio. J-03031-X

YOU CAN BE SURE... IF IT'S

Westinghouse

As stainless sheets are received, they're sprayed with a rubberized coating for protection of fine finish during production operations. The layout department marks the sheets for cutting, and they are sent to this 12-foot power shear for straight line cuts.

in the shop

CRUCIBLE STAINLESS

means dependable results

Brake forming, shearing, joining and polishing operations all keep on schedule when Crucible stainless is used. Its structural soundness and metallurgical uniformity insures consistent, dependable results with any conventional fabrication technique.

Here's how an experienced fabricator—Peters and Company, Inc., Dorchester (Neponset), Mass.—uses stainless . . .

Sections are joined by continuous heliarc welding; then ground and given a final polish.

The result is gleaming stainless equipment, of high strength, and permanent good looks. This is the all-stainless kitchen of the *Corner House Restaurant*, on the New York State Thruway, at Port Byron.

Punch presses, like this 50-ton job, perform necessary notching and irregular cutting. Sheets are then forwarded to large press brakes, equipped with dies for forming sheets to required shape.

When your job calls for stainless see your nearby Crucible representative. He'll furnish full data, and make quick delivery of the best stainless grades for your application. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE

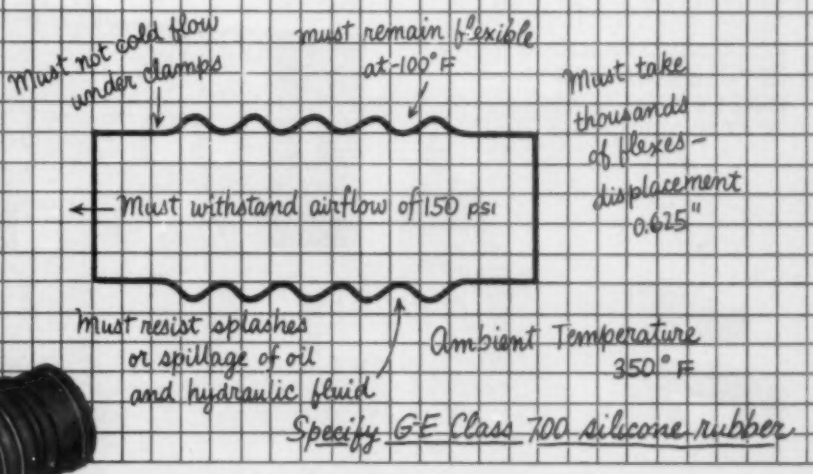
first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

SOLVING DESIGN PROBLEMS WITH GENERAL ELECTRIC SILICONE RUBBER

PROBLEM Find material for flexible heater ducting


Must not cold flow under clamps
must remain flexible at -100° F
Must take thousands of flexes — displacement 0.625"
Must withstand airflow of 150 psi
Must resist splashes or spillage of oil and hydraulic fluid
Ambient Temperature 350° F
Specify G-E Class 700 silicone rubber

SOLUTION

DUCTS MADE FROM G-E CLASS 700 SILICONE RUBBER—

RESISTS 600°F, FLAMES AND FUELS

Problems like this in aircraft de-icing, engine-warming and cabin-heating ducts are being successfully solved with General Electric's improved Class 700 silicone rubber. With a service range from —120° to 600°F, ducts made of G-E Class 700 resist prolonged heat at 600°F, can carry hot air up to 700°F. Tests prove good resistance to common aircraft fuels and lubricants, including MIL-L-7808. Ducts made from Class 700 G-E silicone rubber exhibit low compression set—will not "cold flow" under clamps. And with improved flame resistance, an important safety feature, Class 700 is proving to be the ideal material for all flexible hot-air ducting applications.

High temperature ducting is only one application of Class 700 G-E silicone rubber. It may also be molded, extruded or calendared on cloth to form seals and gaskets for a wide variety of applications.

Where can YOU use G-E silicone rubber?

There's a kind of G-E silicone rubber for almost every requirement, classified according to dominant property for easy selection and specification. For example: Class 300 offers the best recovery after compression *of any known rubber!* Class 500 provides flexibility *at 150°F below zero!* Which class is best for *you?*

For more details on G-E silicone rubber, see your "Sweet's Product Design File" or MAIL COUPON TODAY!

SILICONE RUBBER
Outstanding resistance to extreme temperatures
Superior resistance to compression set
Electrical properties stable at high temperatures
Unequalled resistance to aging, ozone, weathering

Progress Is Our Most Important Product

GENERAL ELECTRIC

SILICONE PRODUCTS DEPARTMENT Section 71-1D,
GENERAL ELECTRIC COMPANY Waterford, New York

Please send me technical data on G-E silicone rubber for _____
(Specify area of application.)

Name _____

Position _____

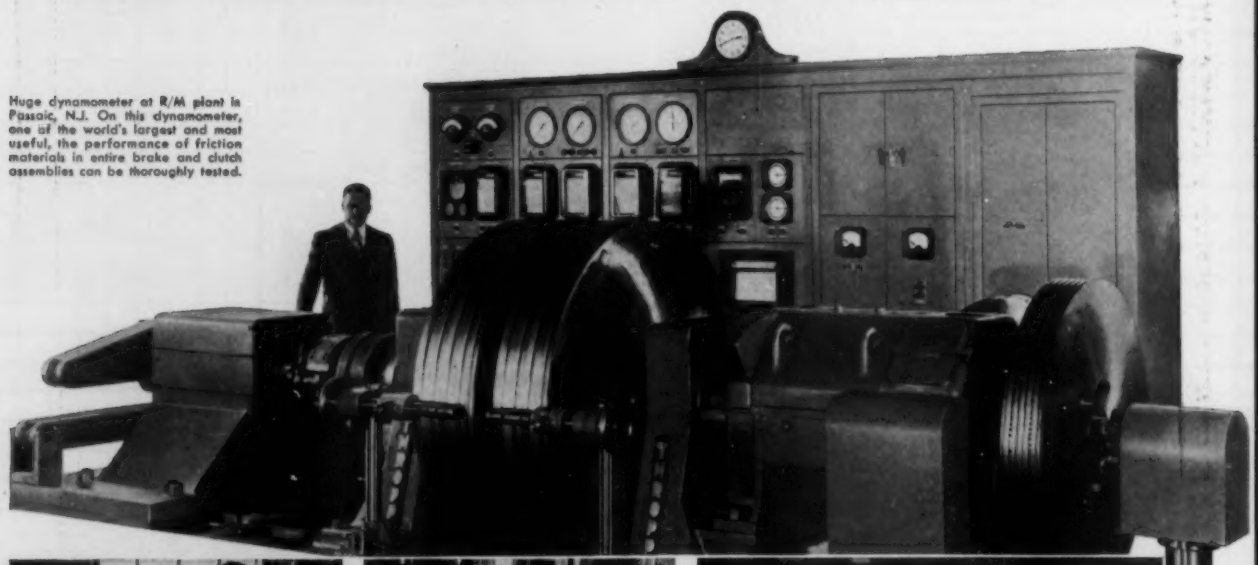
Firm _____

Street _____

City _____ Zone ____ State _____

IN CANADA: Mail to Canadian General Electric Company, Ltd., Toronto

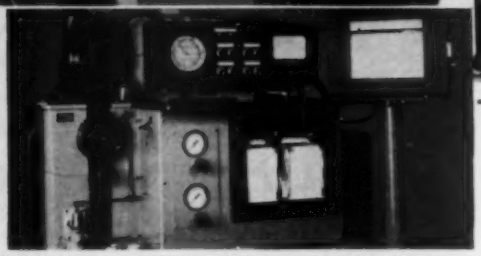
CALL ON R/M ENGINEERING SERVICE



Huge dynamometer at R/M plant in Passaic, N.J. On this dynamometer, one of the world's largest and most useful, the performance of friction materials in entire brake and clutch assemblies can be thoroughly tested.

Two clutch tests can be performed simultaneously on this Long clutch machine at the R/M plant in Manheim. Friction and wear characteristics are tested continuously.

Aircraft landing and takeoff conditions are approximated on this heavy duty inertia dynamometer in the R/M plant at Bridgeport, Conn.



On R/M dynamometers a special Uni-Tork valve invented by R/M subjects brakes to a uniform rate of deceleration and helps produce test data more successfully related to field conditions than possible heretofore.

LAB AND FIELD TESTING SOLVES FRICTION PROBLEMS YOU MAY BE FACING NOW

The one sure way to learn how friction materials will perform in new applications is to test them—in the laboratory or in the field—and see. That's why Raybestos-Manhattan, world's leading maker of friction materials of all types, has the world's most complete, most adaptable testing facilities.

R/M testing equipment ranges from comparatively simple machines to giant inertia dynamometers, including one of the biggest ever made.

Much of this testing equipment was actually designed by Raybestos-Manhattan. And with it, the behavior of friction materials in applications ranging all the way from heavy duty railroad brakes to tiny fishing reel drags can be thoroughly and accurately explored for you by R/M engineers.

Remember, unlike any other manufacturer, R/M works with *all* kinds of friction materials—from woven and molded asbestos to cork-cellulose and sintered metal—and tests all kinds. As a result, R/M has acquired a wealth of knowledge about friction material performance that could solve problems *you* may be facing.

If you are working with friction materials, call in an R/M representative now. The complete facilities of R/M's seven great plants, with their research and testing laboratories, are as near as your telephone.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
Bridgeport, Conn.

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

FOR HELP IN SOLVING YOUR PROBLEMS

R/M FABRIC PISTON CUPS...

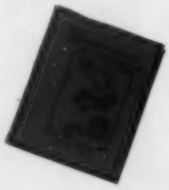
quality where it counts

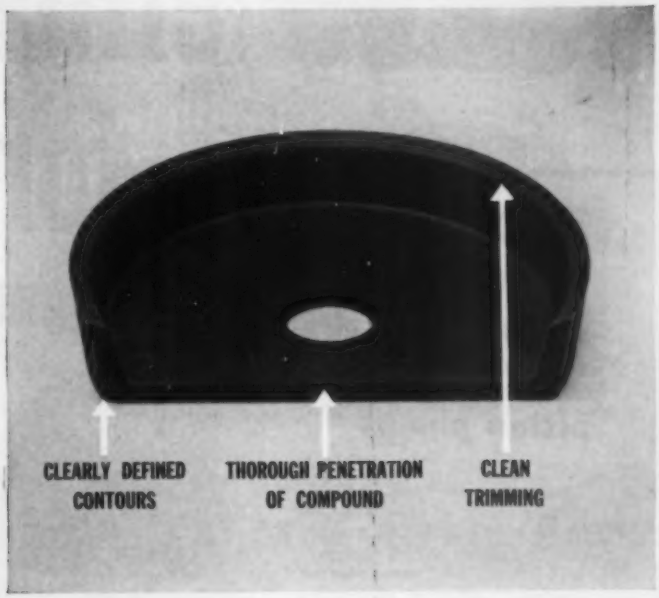
If you want top performance in hydraulic and pneumatic applications, specify R/M Fabric Piston Cups. Here's why: precision molding produces dimensional uniformity and completely effective sealing; polymer-saturated fabric prevents internal destruction from wicking action, resists ply delamination. Furthermore, careful quality control assures consistent hardness and strict adherence to industry standard sizes.

The full R/M line includes packings and gasket sheets for use against gases, water, steam, oil, chemicals, solvents and food products. Feel free to call on R/M's specialized engineering service, if you have a problem involving any of these materials or products.

For booklet shown, or other data, write, phone or wire:

PACKING DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000





R/M ENDLESS BELT

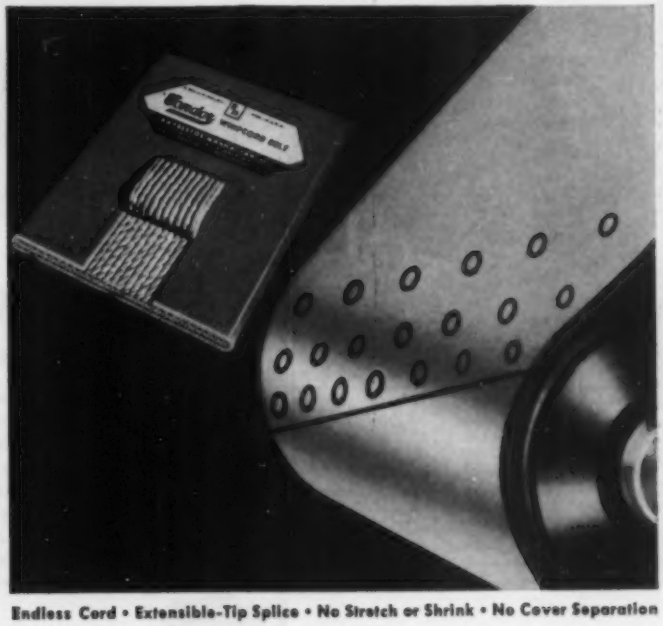
Outlasts 3 to 10 Ordinary Belts

Only *one* take-up in over 3 years of 24 hour daily service "proved" Condor Whipcord Endless Belt on a pulp beater drive . . . and it can do the same for the equipment you design! Endless wound, sealed-in cord construction offers exceptional advantages in drives with short centers, small take-up, small pulleys, reverse bends, high speeds, or heavy loads at high tensions.

Condor Endless Belts are unaffected by moisture and atmospheric changes, and with exclusive "Extensible Tip" cover splice and rubber rivets they have outlasted 3 to 10 ordinary belts on many drives. If your design calls for endless transmission belts—or conveyor belts, V-belts, hose, molded rubber products—let an R/M industrial rubber specialist work with you.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
GRegory 3-2000



Endless Cord • Extensible-Tip Splice • No Stretch or Shrink • No Cover Separation

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R/M

NEW efficiency! New for hydraulic

DYNEX announces a new line of BLACKHAWK 3000 psi piston pumps

These units are capable of operating under severe conditions up to 3000 psi. They provide the hydraulic circuit designer with flexibility never before available. Offering efficiencies over 90%, these units can be used with smaller components . . . heating problems are reduced plus many other advantages. They are ideal for agricultural, construction equipment, materials handling, test stand and press applications.

SPECIFICATIONS — 3000 psi PISTON PUMPS					
DESCRIPTION	PF-3003	PF-3006	PF-3008	PF-3016	PF-3021
MAX. intermittent pressure (psi)	3000	3000	4500	4500	4500
Rated pressure (psi)	2000	2000	3000	3000	3000
Displacement per rev. (cu. in.)	.382	.597	.810	1.568	2.095
Maximum rpm	2200	2200	2200	1800	1800
GPM @ 1800 rpm (max.)	2.65	4.15	5.7	10.9	14.7
Maximum hyd. hp.	5.2	8.2	13.8	24.5	33.0
Weight (lbs.)	25	25	38.5	75	95

PF-3006
3000 PSI
4.15 GPM@1800 RPM

At last!

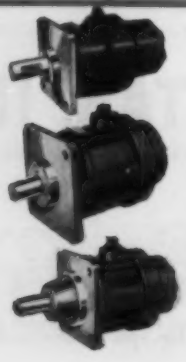
A piston pump in the price range of gear and vane types

Surprising new economies and new design advantages for hydraulically controlled equipment are created by this unique Blackhawk piston pump. Its outstanding design characteristics are available '. . . at an *unusually* low cost . . . because of large-scale production.

The compact PF-3006 pump has proven extremely rugged under severe operating conditions, withstanding continuously repeated shock pressures through millions of cycles.

. . . and a broadened line of 6000 PSI piston pumps

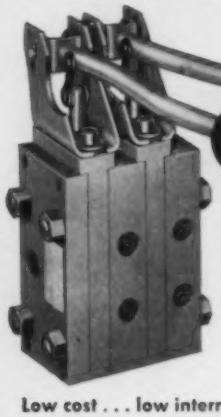
•High efficiency for hydraulic circuits



SPECIFICATIONS — 6000 psi PISTON PUMPS				
Series	P-237 (PF-6006)	P-280 (PF-6011)	P-240 (PF-6015)	PF-6028
Rated pressure (psi)	6000	6000	6000	6000
Displacement per rev. (cu. in.)	.576	1.112	1.485	2.803
Maximum rpm	2200	1800	1800	2400
GPM @ 1800 rpm (max.)	4.2	7.3	9.5	20.5
Maximum hyd. hp.	13.8	24.5	33.0	90.0
Weight (lbs.)	38.5	75	95	150

These piston pumps do far more than answer growing demands for greater pressures. They also bring low cost as compared to other piston pumps — plus up to 95% overall efficiency. Pressures developed by these pumps solve many of the design engineer's most acute problems, dramatically reducing size of valves, fluid lines and cylinders.

low cost! New flexibility circuits

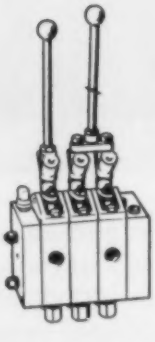


NEW!

BLACKHAWK "VALVBANK" for 3000 psi circuits

Low cost . . . low internal leakage . . . compact construction . . . single or multiple sections.

Blackhawk new Series VM-3506 Sliding Plate Valve designed for 6 gpm, 3000 psi circuits, is a precision-built 3 position (raise-hold-lower) directional valve.



Series V-68 Poppet-type "Valvbank" for 6000 psi

This positive-sealing, directional control valve provides single and double-acting control units for pressures up to 6000 psi. Features integral relief valve with single or multiple sections.

How to make a low cost multiple pump

On all 6000 psi pumps, one or more pistons can be isolated to provide two or more sources of flow by simply removing the check-ball retainer and replacing with a Blackhawk isolating valve VC-6000.

DELIVERIES FROM STOCK

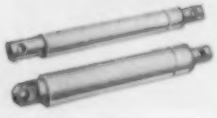
Manufacturing has already expanded so that Dynex offers FROM-STOCK-DELIVERY of most of the components cataloged. And, because of continuous production of standardized items, we can serve both large quantity OEM requirements and individual applications from constantly replenished inventory. In addition, authorized Blackhawk service depots are strategically located throughout the nation . . . and are equipped to provide fast, low-cost repair service.

COMPONENTS AVAILABLE INDIVIDUALLY OR IN COMPLETE CIRCUITS

Dynex offers a long line of standardized hydraulic components — pumps, motors, valves and cylinders. Quality construction and design refinements gained through years of experience offer long life under most rugged conditions. They are furnished individually or in complete circuits.

Write, wire, phone. You are invited to contact us for engineering counsel and added data for the successful application of Blackhawk hydraulic components. Write for free Bulletin No. DG-1 for full information on this extensive and continually expanding line.

Hydraulic cylinders — single or double-acting with exclusive leakproof designs for pressures up to 6000 psi.



DOUBLE ACTING CYLINDERS

RAM NO.	CYLINDER CODE NO.	EFFECT. AREA	MAX. PSI PUSH	TONS PUSH	MAX. PSI PULL	TONS PULL
RA800-2	CD-1509-75-00	1.862 1.0936	5300	5	5500	3
R945	CD-1515-75-00	1.862 1.101	5300	5	5500	3
RA810-1	CD-2009-57-01	3.267 1.5365	7300	12	5200	4
RT910	CD-2009-57-02	3.267 1.5365	7300	12	5200	4
R947	CD-2022-56-00	3.267 1.5365	7300	12	5200	4
R444	CD-2607-52-00	5.1573 4.3719	2000	5	2000	3
R551	CD-2610-52-00	5.1573 2.9208	2000	5	2000	3
RA820	CD-2609-55-00	5.1573 2.0646	7750	20	4800	5
RA830	CD-3009-56-00	7.2678 2.4202	6000	22	4900	6
RA698-1	CD-3526-56-00	9.6212 2.6991	7300	35	6000	8

DYNEX, Inc.,

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1500 S. Muskego Ave.,
Milwaukee 4, Wis.
is a development of the
HYDRAULIC CONTROL DIVISION
of BLACKHAWK MFG. CO.

BLACKHAWK
HYDRAULIC CONTROLS

There's been a revolution going on under the surface!

Sleeve bearings have *looked* much the same for 50 years. But there the resemblance ends. Take this modern bearing, for example. It has a steel back, a sintered layer of copper-lead alloy, a brass barrier plate and a lead-tin overplate. It's a far cry from the simple babbitt bearings of the past—but so are the load, speed and temperature complications facing today's engine builders. Tomorrow there will be demands for new types of bearings . . . and designers and manufacturers will team up with Federal-Mogul Engineering to create and produce them. *Your* inquiry is invited now.

FEDERAL Mogul
SINCE 1899

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11043 SHOEMAKER, DETROIT 13, MICHIGAN

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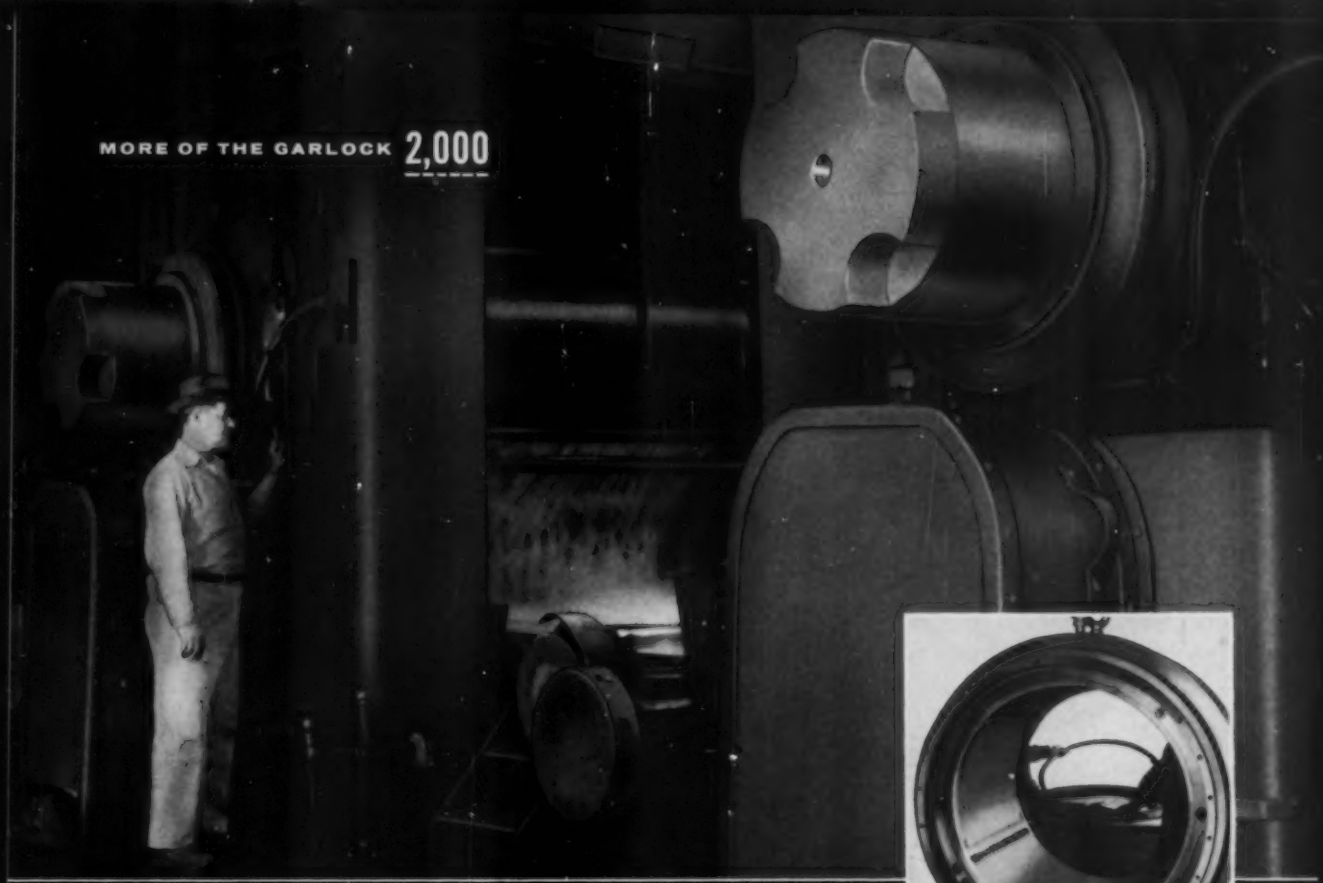
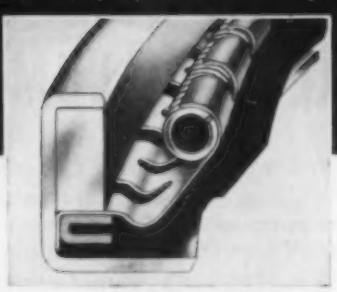


YOUNGSTOWN Equips Hot Strip Mills with Garlock KLOZURE* Oil Seals . . . SAVES OIL and MAINTENANCE TIME

Photo shows roll bearing in foreground with KLOZURE Oil Seal and retainer ring removed. In background a new KLOZURE Oil Seal is quickly inserted in retainer ring.



Cross section of Model 64 KLOZURE Oil Seals used on back-up rolls of steel mills.

Nine back-up rolls on the Hot Strip Mill illustrated have been equipped by Youngstown Sheet & Tube Company with 72 Garlock KLOZURE Oil Seals. The rolls run at speeds of 1025 ft. per min. Oil pressure is approximately 8 psi. at temperatures to 120° F.

Youngstown is able to roll a half a million tons of steel on this Mill before the KLOZURE Oil Seals need replacement. Furthermore, considerable maintenance time is saved when replacement seals are applied.

Also, a large percentage of oil has been saved due to the application of Garlock KLOZURE Oil Seals.

If you have an application that requires oil seals, why not investigate the advantages of KLOZURE Oil Seals. They are another important part of "the Garlock 2,000" . . . two thousand different styles of packings, gaskets, and seals for every need. It's the only complete line . . . that's why you get unbiased recommendations from your Garlock representative. Call him or write for KLOZURE Catalog.

THE GARLOCK PACKING COMPANY, Palmyra, New York

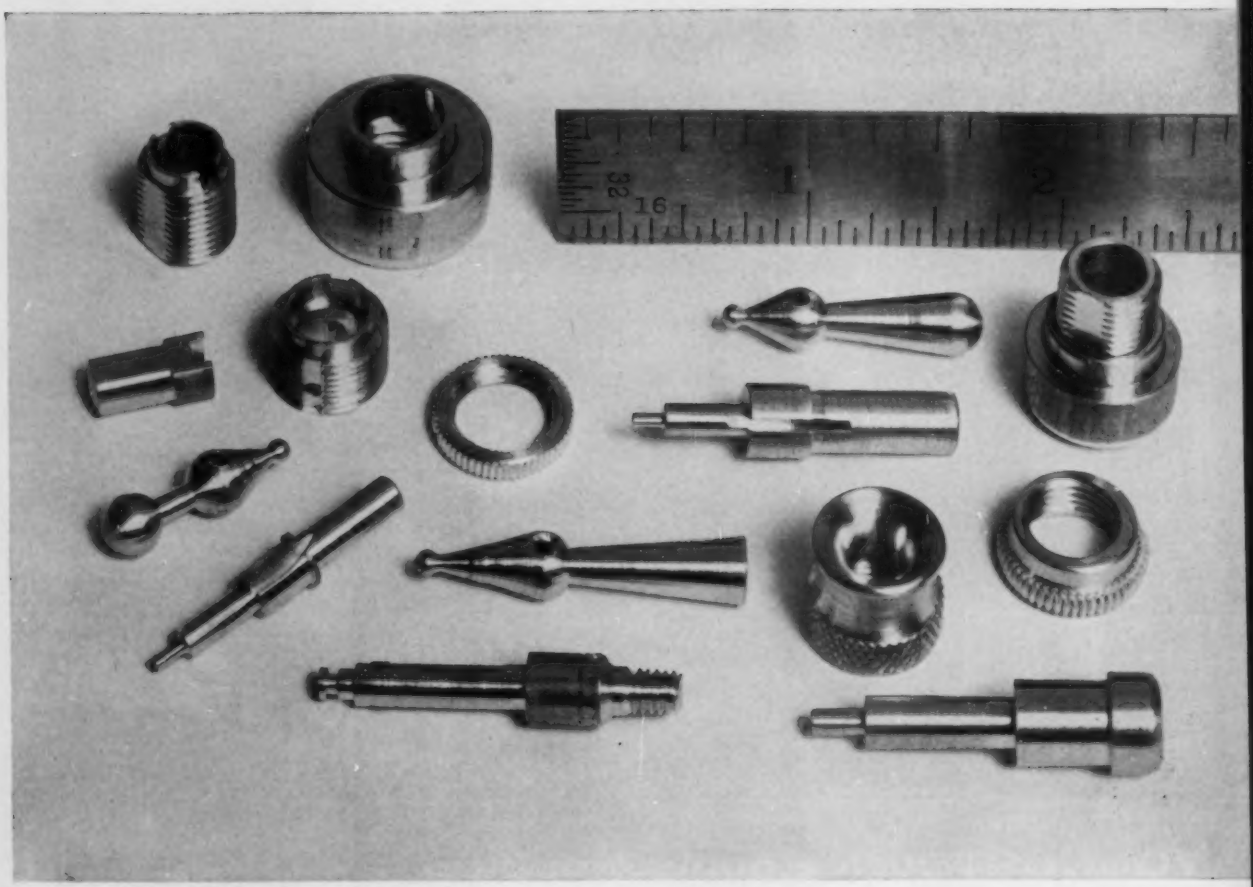
For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U.S. and Canada.

**Registered Trademark*

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints

IN MANAGEMENT



Typical parts machined by Leviton Manufacturing Company from Alcoa Aluminum Screw Machine Stock

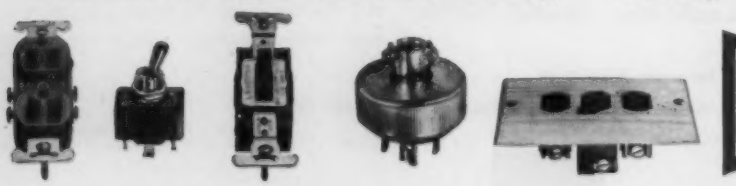
WHEN LEVITON MAKES A SWITCH, THEY USE ALCOA ALUMINUM SCREW MACHINE STOCK

Leviton Manufacturing Company first substituted aluminum for scarcer materials. Today, new parts are designed first for aluminum, and the other materials are viewed as substitutes.

For over thirty years, Leviton has specialized in the manufacture of fine electrical wiring devices for residential, commercial and industrial use. Today the company is the largest in its field and operates a huge main plant in Brooklyn, New York. Other plants are at Hillsgrove, Rhode Island; Montreal, Canada; Chicago and Los Angeles, with sales offices in all major cities of the United States and Canada.

Whether you make parts for the electrical industry, like Leviton, or market your products elsewhere, you'll find you can't beat Alcoa® Aluminum Screw Machine Stock for quality and economy. Cutting speeds as high as 1,000 feet per minute are not uncommon. Aluminum resists corrosion, offers excellent heat and electrical conductivity. Its light weight gives you up to three times as many parts per pound.

Alcoa wants to help you profit from aluminum screw machine stock's many advantages. Just call your nearby Alcoa sales office, listed under "Aluminum" in your phone book. Aluminum Company of America, 865-B Alcoa Building, Pittsburgh 19, Pennsylvania.



LEVITON

IN MANAGEMENT

Bernard Leviton, Executive Vice President and spokesman for the Standards Committee says, "Alcoa has been one of our suppliers since 1941. Since then, we have had a steady progression of changes to aluminum. Ours is a high-volume, high-production business. In any case where we've had a problem—whether materials, packaging or machining—Alcoa has the right man on the spot in 24 hours. And that man has the right answers. Alcoa's technical services are, in effect, an actual part of our developmental facilities. The jobs we've worked out together meet the high standards of Underwriters' Laboratories and Canadian Standards Association. At every level, Alcoa has made sure we are satisfactorily served."

IN ENGINEERING

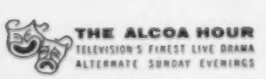
George Smith, Chief Engineer, says, "We think Alcoa's engineering data and technical assistance set the standard and give us firm foundations of fact on which we can make decisions. I recall one specific case of many . . . Alcoa lubrication engineers gave us information that enabled us to increase tool life dramatically. Typical of the aluminum screw machine parts we make are components for toggle switches, including bat handles, bushings and mounting nuts. Close tolerances are a must. A variation of as little as .001 inch in some switch parts means the device just won't work. Yet, with aluminum, the parts fit together nicely, work smoothly."

IN PRODUCTION

Edward Palczewski, Foreman of the Screw Machine Department (shown with operator), says, "We've been cutting aluminum during the ten years I've been with Leviton. We have one job running on a high-speed Davenport which does 120 pieces a minute. It consists of forming, drilling, tapping and threading 1⅝-inch rod. We're running the machine at top capacity. Swaging diminishes the machinability of some metals—takes away their free-cutting qualities. Aluminum's properties are retained no matter what we do with it—doesn't get stringy or lose machinability. During setup, tools can be set dry. The operator can see what he's doing—saves a lot of time. Cutting oils are lighter, cheaper. Stock is easier to handle."

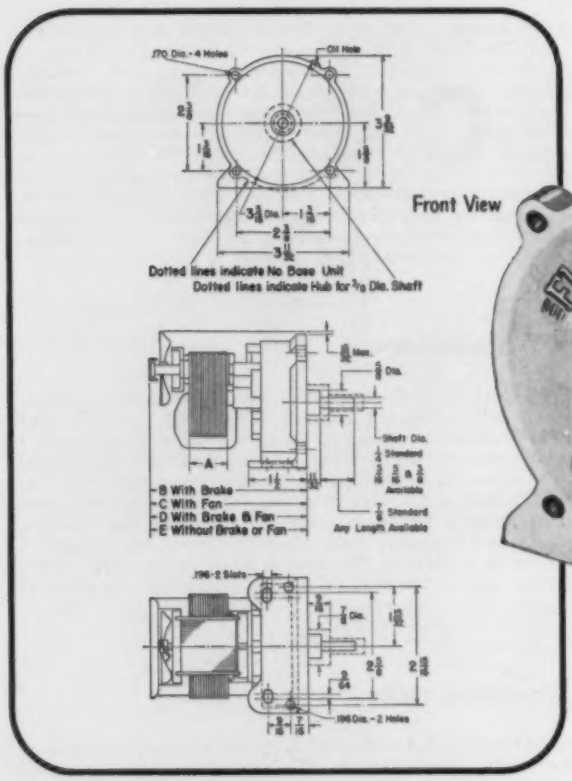
IN PURCHASING

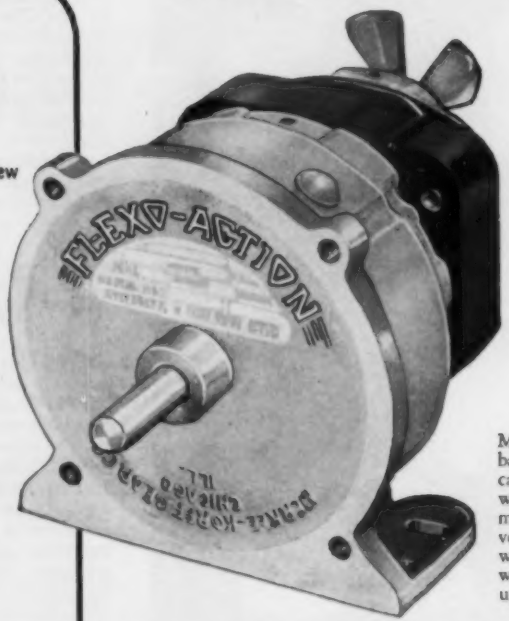
Joseph Wolfson, Purchasing Agent, says, "Our Purchasing Department at Leviton demands dependability from suppliers. It is this simple fact that has characterized our relationship with Alcoa for over 15 years. Use of Alcoa Aluminum Screw Machine Stock has helped us to reduce our inventory and order problems; for example, one Alcoa alloy offers advantages of free cutting and free swaging. Once, when we increased production on a certain job and ran into low-stock problems, Alcoa's early delivery service really helped us out."



Your Guide to the Best in Aluminum Value

POWER UNDER CONTROL


Front View
Dotted lines indicate No Base Unit
Dotted lines indicate Hub for ⅜ Dia. Shaft
B With Brake
C With Fan
D With Brake & Fan
E Without Brake or Fan
Standard
Any Length Available



Model SG25 with base case. This unit can also be furnished with no base for face mounting, with inverted base, or side wall mounting, or with shaft vertically upward.

Stator Thickness and Corresponding Length				
A	B	C	D	E
9/16	3⅛	3¼	3 9/16	2⅞
1 5/16	3½	3⅞	3 1 5/16	3¼
1½	4 7/16	4¾	4 1 5/16	4¼

How To Buy the Right Geared Motor for Your Job

Measure the speed and torque required when possible. If torque can't be measured make a realistic estimate. Buying a motor that is too strong can be just as harmful as buying one that is too weak.

Be sure to specify direction of rotation, if uni-directional, or reversing if required. Will the motor operate continuously or is the duty cycle intermittent? Specify the type motor required for the job—whether induction or synchronous, AC, DC or universal.

Experienced Merkle-Korff application engineers can assist you in choosing the right unit for the job. They will recommend a fractional horsepower geared motor with an ample margin of safety to meet overload or low voltage conditions.

Merkle-Korff has been building a product of proven quality for years and can deliver motors *on time* to fit your production schedule.

A typical torque table is shown. This table shows no-load speeds for uni-directional shaded pole induction motors. The loads are the maximum under which the motor will start and operate continuously without over-load. The speeds shown are those commonly used. If the maximum rated torque is required at speeds greater than shown, modifications can usually be made. Units can be furnished at speeds as low as 1 RPH or slower.

Merkle-Korff builds a varied line of fractional horsepower geared motors. For detailed dimension drawings, mounting styles and torque tables of the complete line, write for engineering data sheet PE2.

TORQUE TABLE - LB. IN.
MODEL SG-25

	stator thickness and torque		
rpm	9/16"	1 1/16"	1 1/2"
300	1.2	1.5	3.0
150	2.3	3.0	6.0
100	3.5	4.5	9.0
60	6.0	7.5	15.0
45	6.6	9.0	17.0
30	10.0	13.0	26.0
25	12.0	16.0	30.0*
20	15.0	20.0	"
15	20.0	26.0	"
12	25.0	30.0*	"
10	30.0	"	"

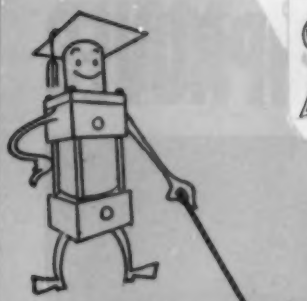
* At these speeds and lower the units will deliver more torque than is shown on the tables. The output shaft should not be loaded above the value shown on the table. This is the rated capacity of the gear case.

MERKLE-KORFF GEAR CO.

219 NORTH MORGAN STREET • CHICAGO 7 • ILLINOIS

Miller

FLUID PRESSURE BOOSTERS

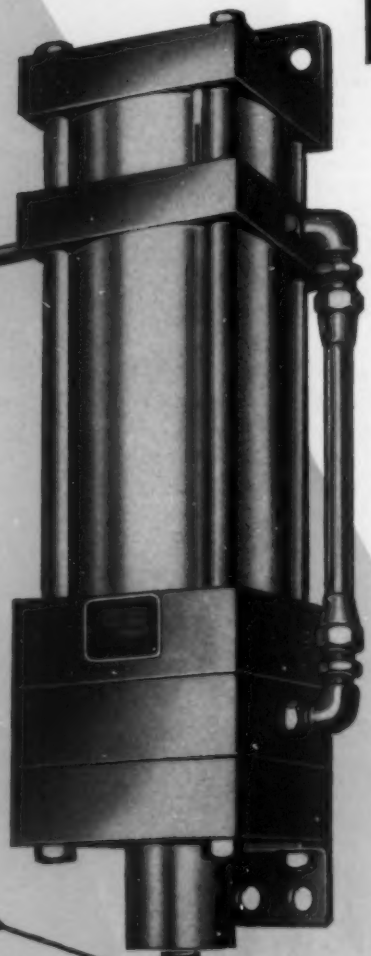


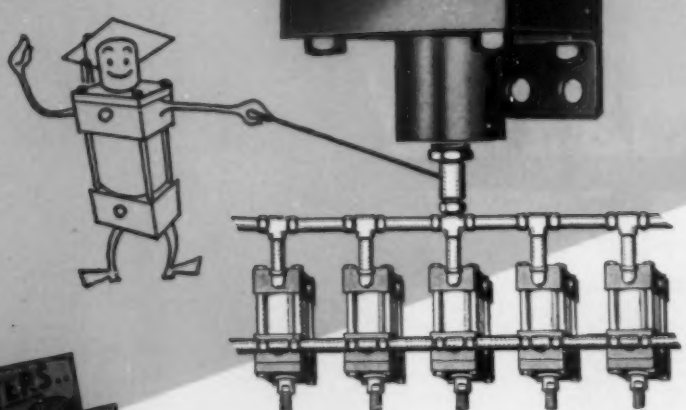
BOOST 80 PSI AIR

Input Range: 40 to 3000 psi Air or Fluid

TO 2000 PSI HYDRAULIC PRESSURE

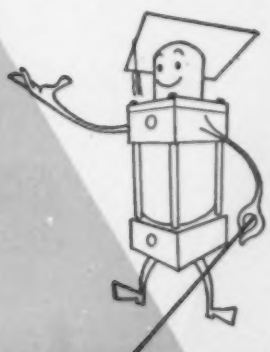
Output Range: 200 to 10,000 psi Fluid





- Save space, weight and investment cost by replacing pump installations in many applications.
- Less costly to install, operate and maintain.
- **Hold Pressure indefinitely** without the motion and heat generation of ordinary pump circuits.
- Provide—at point of cylinder thrust—more efficient power with less weight in less space than direct driven air cylinders.
- Save up to 95% of air consumed by direct driven air cylinders.
- Operate at speeds of 30 to 450 strokes per minute.

NOTE: In addition to its most complete line of "Custom-Built" Boosters available on normal delivery Miller offers 5" bore, 25 to 1 ratio boosters for immediate delivery in either 6" or 12" stroke. Write for data and prices.



ESPECIALLY RECOMMENDED FOR

- **WELDING**
- **PUNCHING**
- **SHEARING**
- **CLAMPING**
- **RIVETING**
- **CRIMPING**
- **PRESSING**

and similar applications

FULL DETAILS IN MILLER BULLETIN B-200 SENT FREE ON REQUEST
Other Miller products include: Air cylinders, 1½" to 20" Bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

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Miller

MILLER FLUID POWER DIVISION FLICK-REEDY CORP.

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AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

HOW USS "T-1" STEEL IMPROVES

They Couldn't Be Built Without "T-1"... Only the unique combination of properties found in USS "T-1" Steel—very high yield strength, toughness, and excellent weldability—could make these two huge pressure vessels possible. In carbon steel, the shell walls cannot be over 1¼" thick—the maximum permissible without stress relieving after welding. The diameter would therefore be restricted to 79.17 feet. As a result, 6 vessels, weighing 2½ times as much, would have been required to provide the same capacity as just these *two* USS "T-1" Steel vessels. These vessels—each 110½ feet in diameter, with a net capacity of 707,000 cu. ft. and shell walls only 0.73" thick—were erected in Japan for Tokyo Gas Works, Ltd. They were designed and fabricated in the United States by Chicago Bridge & Iron Company.

THESE PRODUCTS:

75-Mile Trip Eliminated—Now made of USS "T-1" Steel, the forks on this lift truck no longer need to be sent 75 miles for heat treatment. In addition, the high strength of the new steel reduced the width and thickness of the forks. This lift truck is the largest standard-line lift truck on pneumatic tires in the world. Manufactured by Gerlinger Carrier Company, Dallas, Oregon, it is shown here in use at Baltimore Concrete Plant Corporation.

More Ore, More Often—The great strength of USS "T-1" Steel helps boost the volumetric capacity, reduce the weight, and speed operation of this new rear-dump trailer that is used to haul high-volume, lightweight materials. Drawbar and draft frame structure, as well as all load-containing body plates, were fabricated from USS "T-1" Steel. This permitted working stresses above those permissible with commonly used steels and resulted in a weight saving of 3½ tons. Trailer was designed and built by Athey Products Corporation, Chicago, Illinois.

YOU GOOD AT GUESSING WEIGHT?

You can win a prize at the Design Engineering Show in May by just guessing the combined weight of the flame-cut steel "T" and "1." Stop at the United States Steel exhibit to see this steel trademark, make your calculations and enter your guess. You could easily be one of the winners of the useful prizes which will be awarded.

Meanwhile, though, send for your copy of the new and revised booklet about USS "T-1" Steel. It contains up-to-date information on properties, applications and fabrication of this remarkably versatile constructional alloy steel. Write to United States Steel, Room 5573, 525 William Penn Place, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS

UNITED STATES STEEL

The drafting stage—not later—is the time to design-in oil seals!

Oil seals are precision products. They are designed to operate under a specific set of conditions. Change just one of those conditions—lubricant, shaft speed, temperature, even bearing position—and a different seal will almost always be needed.

Why chance costly retooling or remanufacture? Specify the correct seal on the drawing-board. And when you do, get all the information there is on new seals, new lip compounds, and mechanical designs. Get it from your National Oil Seal Engineer. His counsel is complete, up-to-the-minute, and accurate. You couldn't buy better oil seal information, yet his help is yours for the asking.

Why "do it yourself?" Call the nearest National Oil Seal Engineer now.

NATIONAL SEAL
DIVISION, Federal-Mogul-Bower Bearings, Inc.
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PLANTS: Van Wert, Ohio and Redwood City, California

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Precision Metal Stampings

for Lady Schick come from Sylvania

A fast-selling precision-made product like the Lady Schick electric shaver calls for custom-made precision parts in great quantities. That's why Schick, inventors of electric shavers, called in Sylvania's Parts Division to fabricate critical parts for the beautiful Lady Schick.

Sylvania is known for its ability to supply high-volume production of quality component parts, custom-made to dimensional precision.

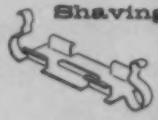
Furnishing metal stampings is only one way Sylvania's 4-way service can help manufacturers and designers of mass-produced quality products. If your product involves custom-molded plastic parts . . . plated or clad specialty wire . . . electronic components . . . or metal parts—look to Sylvania as a dependable source of supply.

For the complete story, write for the Portfolio of 4-way Service to Designers.

Matched Components critical for gentle action

The shaving head of the Lady Schick requires component parts fabricated to precision accuracy. Manufactured of SAE 1080 Cold Rolled Steel, all tolerances are held to ±.005 or less in order to assure accurate alignment during assembly.

Shaving Head Retainer



Spring characteristics of clips and the distance between them are critical in order to firmly hold shaving head assembly. Critical accuracy of retainer tabs and bottom are required for correct positioning of head in case.

Shaving Head Frame

Height of ears are held to a tolerance of +.000 and −.003 to keep cutters in proper alignment.

Retainer Ring

Serrated ring, stamped as complete piece, is critical as to shape and size for snapping into position on the housing of the deluxe Lady Schick. It must be suitable for gold plating.

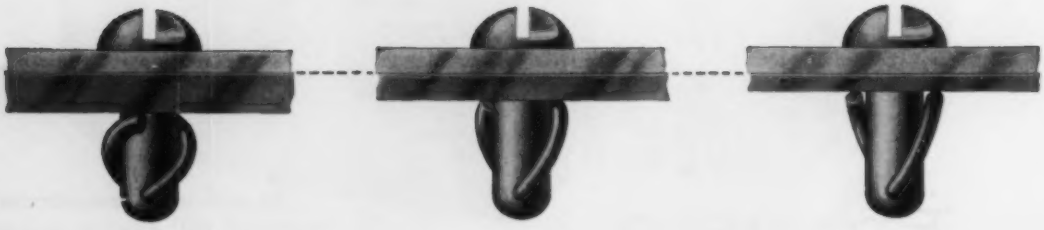
SYLVANIA

PARTS DIVISION

Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania

SPECIAL WIRE · METAL STAMPINGS · MOLDED PLASTIC · ELECTRONIC COMPONENTS · 4-way service from one source

This fastener works through thick and thin!



Spring-Lock—the easy-to-use removable fastener for modern designs—works whether panel thicknesses run over or under specifications! Spring wire deflects automatically to handle greater or lesser thicknesses. Spring-Lock's design flexibility makes it more than a fastener: it can be adapted as a shelf support, door strike, knob or any similar panel-mounted device. Many standard shapes and sizes of Simmons Spring-Locks are available from stock.

SIMMONS FASTENER CORPORATION

1751 North Broadway, Albany 1, New York

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QUICK-LOCK
SPRING-LOCK
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JUST OUT!
NEW 36-PAGE CATALOG WITH APPLICATIONS
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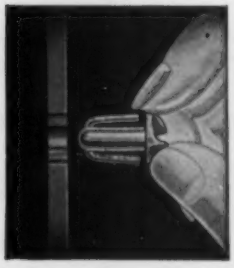
HERE'S HOW SPRING-LOCK WORKS



1. *Insert fastener.*

2. *Half-turn locks it in place.*

With production costs on the uptrend, you can figure on Spring-Lock as an assembly time and money-saver, because:

- **Installation is BLIND**
- **Installation is EASY: no special tools are needed**
- **Installation is QUICK: a half-turn locks it in place**
- **Installation is SECURE: the *spring* steel *locks* the fastener, resists vibration**

Send for details and samples, or write us about *your* fastening problem.

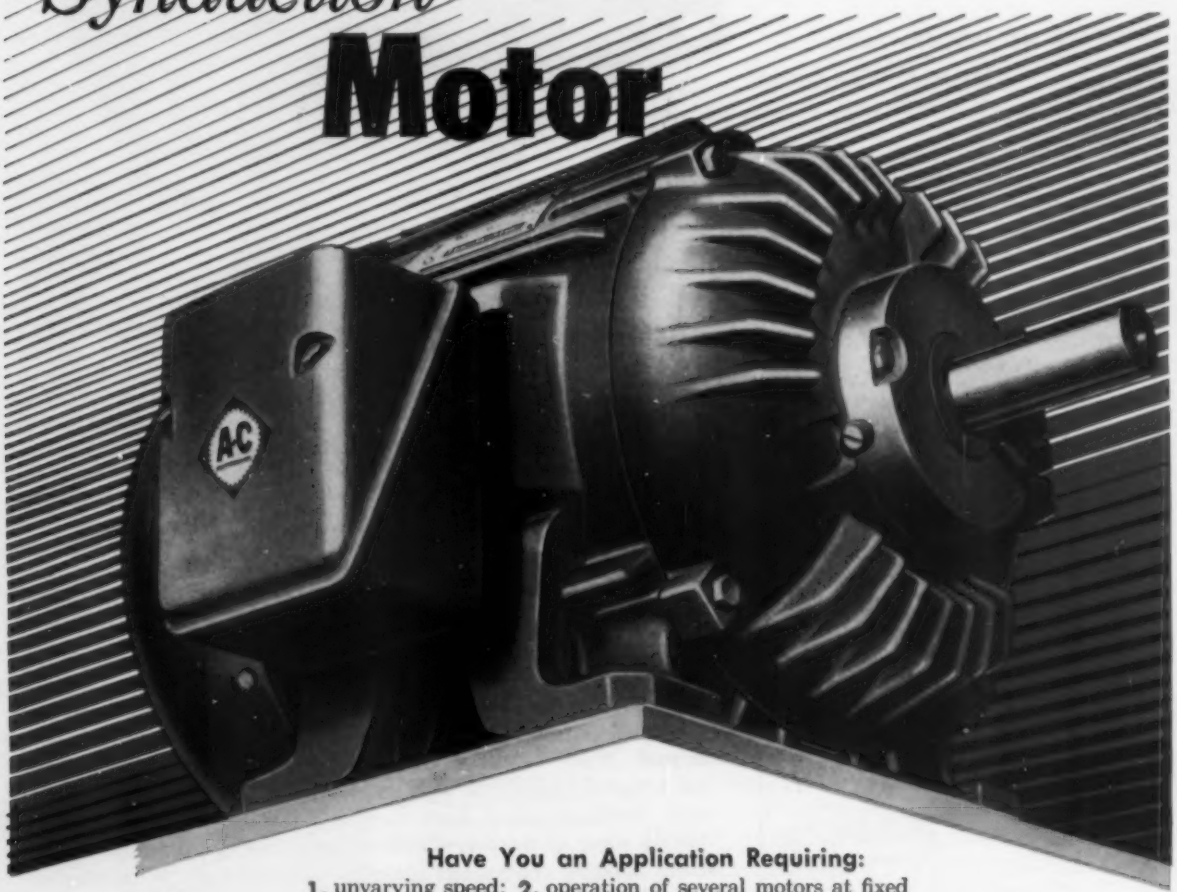
NOW dependable constant speed at less cost

Here's a motor with all the constant speed benefits of synchronous design at initial low cost — with the dependability of an induction motor. It's the NEW *SYNDUCTION* motor, built specially for applications from ¼ to 40 hp.

DEPENDABLE — Now constant speed, regardless of load or voltage changes, is sure . . . depends only on frequency. *Synduction* motor's simple die-cast rotor has no brushes, collector rings, nor insulated rotor windings.

LOW COST—Simple across-the-line control is all that's needed. Further, design permits use of frames smaller than usual reluctance-type motors. Purchase price is well below that of ordinary reluctance-type motors.

New *Synduction* Motor



Have You an Application Requiring:

1. unvarying speed; **2.** operation of several motors at fixed speed ratios; **3.** adjustable speed with minimum variation at any speed setting? If so, Allis-Chalmers invites your inquiry. Contact your nearby A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin, for Bulletin 51B8440.

Synduction is an Allis-Chalmers trademark.

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ALLIS-CHALMERS

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MODEL T-271
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- **NO MOVING PARTS**
  Has no electrical contacts or moving parts
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  Uses no vacuum tubes or other components of limited life
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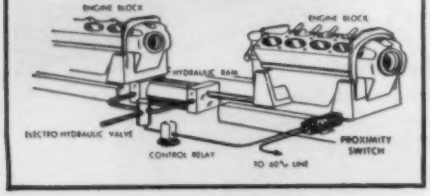
  Requires no physical contact with workpiece
- **FAST RESPONSE**
  Will operate up to 10 times per second
- **POWER REQUIREMENTS**
  Conventional 115 volts 60 cycle source

TYPICAL APPLICATION
PROXIMITY SWITCH ACTUATING ENGINE BLOCK TRANSFER LINE



PROXIMITY SWITCH

MECHANICAL AND ELECTRICAL FAILURES ELIMINATED

The Honeywell Proximity Switch detects the presence of ferrous objects without requiring physical contact. It's a newly developed magnetic device containing no moving parts. Detection is accomplished as the object passes through a magnetic field set up directly in front of the switch's sensing head. The switch transmits an electrical signal which operates a control relay that may be remotely located. Many industrial automation processes are replacing the conventional limit switch with the newly developed Honeywell Proximity Switch to avoid work stoppages due to mechanical failure. Among some of these applications are switching operations in materials handling control and automatic machine tools. *Write for Bulletin PS* . . . Minneapolis-Honeywell, Boston Division, Dept. 47, 1400 Soldiers Field Road, Boston 35, Mass.

MINNEAPOLIS **Honeywell** H HONEYWELL
BOSTON DIVISION

Bob Rossi, Chief Engineer, tells
Roy Johnson, Plant Manager

"We switched to Formbrite —and saved 12 cents apiece!"

.032" gage 70-30 Formbrite is used for this 4½" diameter rearview mirror head shown full size. Strip is $5^{13}/_{32}$" wide supplied in heavy coils for long press runs. Copper, nickel and chromium plating on a solid brass base provides a bright, rustless, long-lasting outdoor finish.

Peerless Rearview Mirrors. "Flight-Wing," below, and the newer "Director" model, left. Housings and mounts are chromium-plated zinc-base die castings.

This easy-to-polish, superfine-grain drawing brass has been slashing finishing costs in plant after plant, on all kinds of jobs. Now Peerless Accessories Co., of Mount Holly, N. J., reports:

"To our line of lighting and safety automotive accessories, we've recently added two rearview mirror assemblies. We had been using regular drawing brass for the dished head until your representative persuaded us to try Formbrite. Here are the results, based on a very careful cost study:

Finishing procedure using regular drawing brass	Present procedure using Formbrite®
1) Grease grinding or "cutting"	Not necessary with Formbrite
2) Buffing	Light buff
3) Copper strike	Copper strike
4) Nickel plate (.00045")	Bright nickel plate (.0003")*
5) Buffing nickel	Not necessary
6) Chromium plate	Chromium plate
Cost 27¢ each	**Cost 15¢ each**

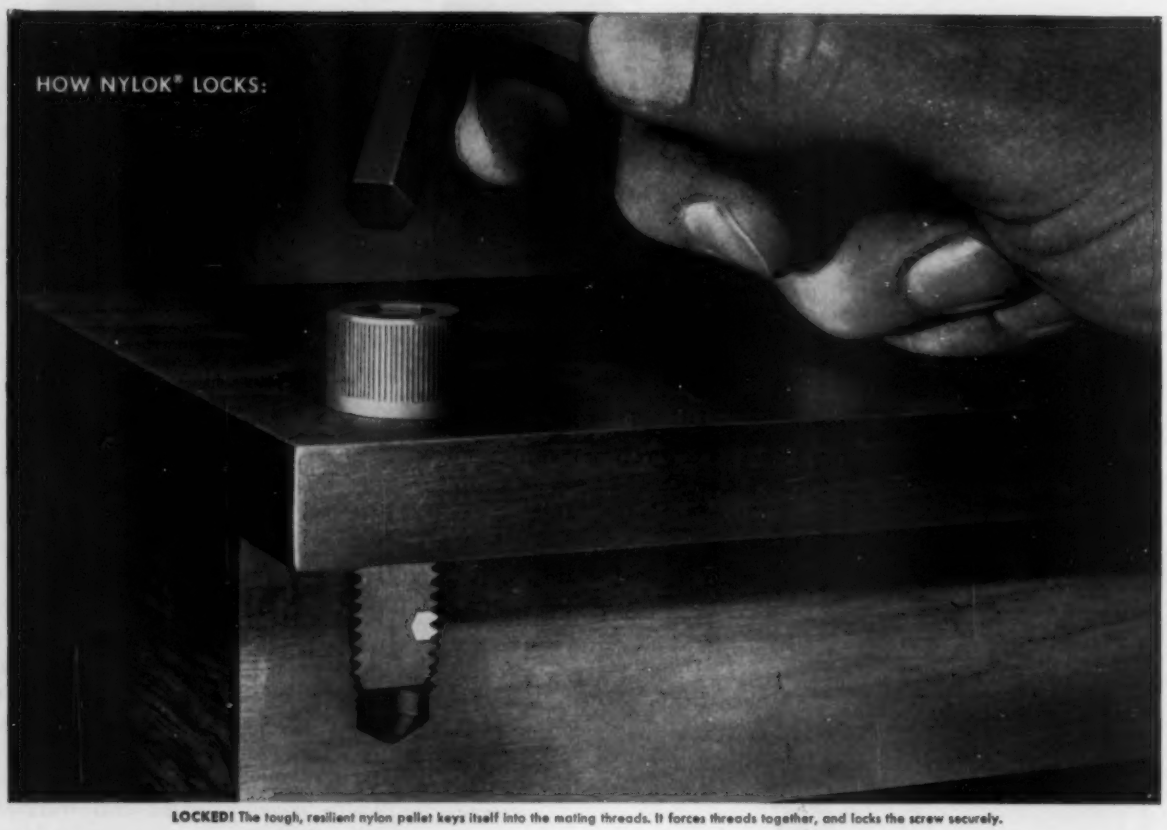
"That's a saving of 12 cents apiece. Multiply it by 3,000 to 4,000 a day and it becomes important money!"

*Formbrite's superfine grain made possible a lighter but equally serviceable plate of *bright* nickel

Surprisingly, Formbrite doesn't cost a penny more. Find out for yourself how its superfine grain, excellent drawing properties, strength, and scratch resistance can help you make a better product at lower cost. Write for Publication B-39. Better yet, ask us about a sample lot. The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 6070

Formbrite FINE-GRAIN DRAWING BRASS

an ANACONDA® product
made by The American Brass Company



LOCKED! The tough, resilient nylon pellet keys itself into the mating threads. It forces threads together, and locks the screw securely.

NEW—a complete line of self-locking UNBRAKO socket screw products that won't work loose

They simplify design and save production time

UNBRAKO socket screws are now available embodying the Nylok* self-locking principle. Nylok provides a truly practical new solution to the problem of making screws self-locking.

You save production time when you build products with self-locking UNBRAKOS. And you get greater simplicity in design with less bulk and weight. The number of parts you must assemble to achieve full locking action is reduced to the absolute minimum. Lockwashers under screw heads are no longer necessary. Costly wiring of cross drilled heads is eliminated. So are cotter pins and complex multiple set screw installations.

Self-Locking UNBRAKOS are completely reusable. They have uniform locking and installation torques—with no galling or seizing on mating threads. They successfully withstand temperatures from —70° to 250°F. And, on properly seated screws, the pellet acts as a liquid seal.

Self-locking UNBRAKO socket screws come in a complete range of standard sizes and materials. See your authorized industrial distributor. Technical data and specifications are detailed in Bulletin 2193. Write us for your copy today. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

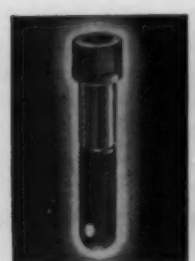
T.M. Reg. U.S. Pat. Off., The Nylok Corporation

UNBRAKO SOCKET SCREW DIVISION

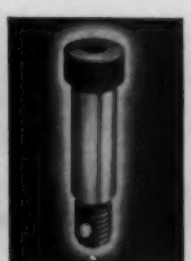
STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA



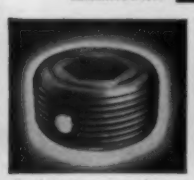
Socket head cap screws. Standard sizes #6 to 1 in.



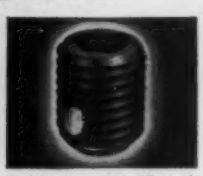
Socket shoulder screws. Standard sizes ⅛ to ⅜ in.

Flat head socket screws. Standard sizes #6 to ¾ in.

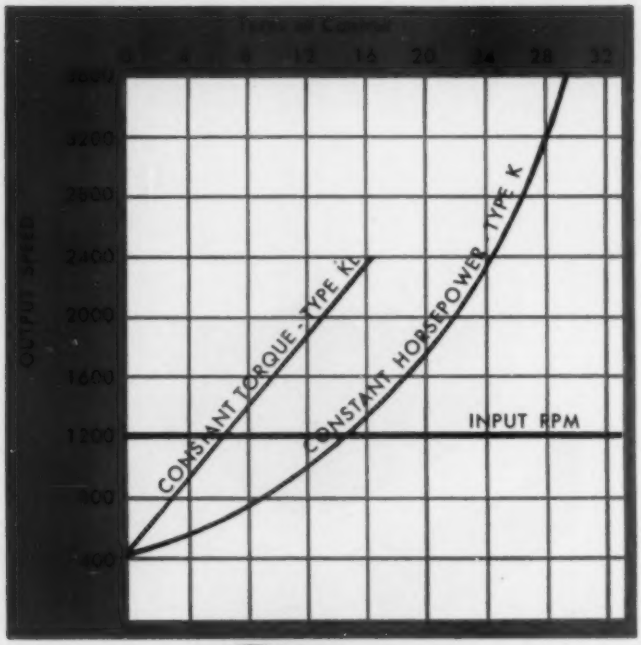
Button head socket screws. #6 to ⅜ in.



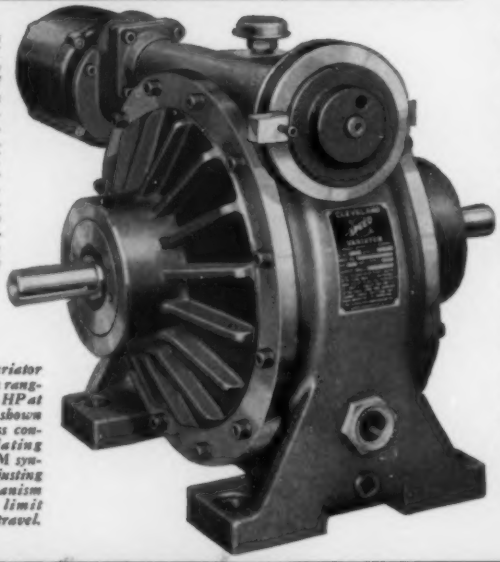
Socket pressure plugs. Standard sizes ⅛ to 1¼ in.



Socket set screws. All standard point types. #6 to 1 in.



Typical speed regulation curves for the Types K and KL Variators. Type KL offers a linear speed regulating pattern, often an advantage in automatic control applications. Output speed regulation of the Type K Variator follows a geometric progression pattern. Starting at the minimum output speed, each turn of the speed regulating wheel produces a fixed percentage increase in output shaft speed.



The Cleveland Speed Variator is available in 18 models ranging from fractional to 16 HP at 1750 input RPM. Unit shown at right, used in process control, has speed regulating worm driven by 75 RPM synchronous motor, with adjusting shaft indicating mechanism modified to actuate limit switches to prevent overtravel.

CLEVELAND SPEED VARIATOR

Accurately Provides Dependable, Infinitely Variable Speed Control

ANNOUNCED late in 1954, the new Cleveland Speed Variator met instant, enthusiastic acceptance. Engineers and designers of industrial equipment already have put thousands of units into use on such varied equipment as cigarette making machines, textile machinery, metalworking machinery, pharmaceutical equipment, transfer tables, conveyors and experimental and testing equipment of many types.

Infinitely variable, the Cleveland Speed Variator gives stepless speed over a full 9:1 range—from ⅓ to 3 times input speed. Output speed can be adjusted by either a hand wheel on the Variator or by manual or automatic remote control.

The Cleveland Speed Variator offers these major advantages:

1. An extremely compact unit with input and output shafts in line and rotating in the same direction.

2. Almost any input speed up to 1800 RPM can be used—either clockwise or counterclockwise rotation.

3. Rated for constant horsepower output over a 9:1 or 6:1 range; or for constant output torque over a 6:1 range.

4. Speeds infinitely variable over entire range of adjustment.

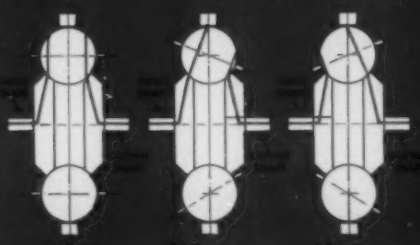
5. No slippage—positive torque response mechanism adjusts in direct proportion to the loads encountered.

6. Long life and minimum maintenance due to absence of belts or complicated linkages.

7. Ample bearing support for overhung pulleys on both input and output shafts.

Write for Bulletin K-200 for detailed description with photographs, sectional drawings, rating tables and specifications.

HOW THE CLEVELAND SPEED VARIATOR WORKS



Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts.

Relative speeds of the shafts are adjusted by changing the positioning of axes on which the balls rotate (diagram, right, shows cutaway Variator with hand regulating wheel).

"It's the Drive That's on the Ball."

THE CLEVELAND WORM AND GEAR COMPANY

Speed Variator Division, 3279 East 80th Street, Cleveland 4, Ohio

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because

– Thousands of manufacturers have been using the **SKF** Bearing Advisory Service for many years – always with good results. This dependable service is available to you, too. 7754

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EVERY TYPE—EVERY USE

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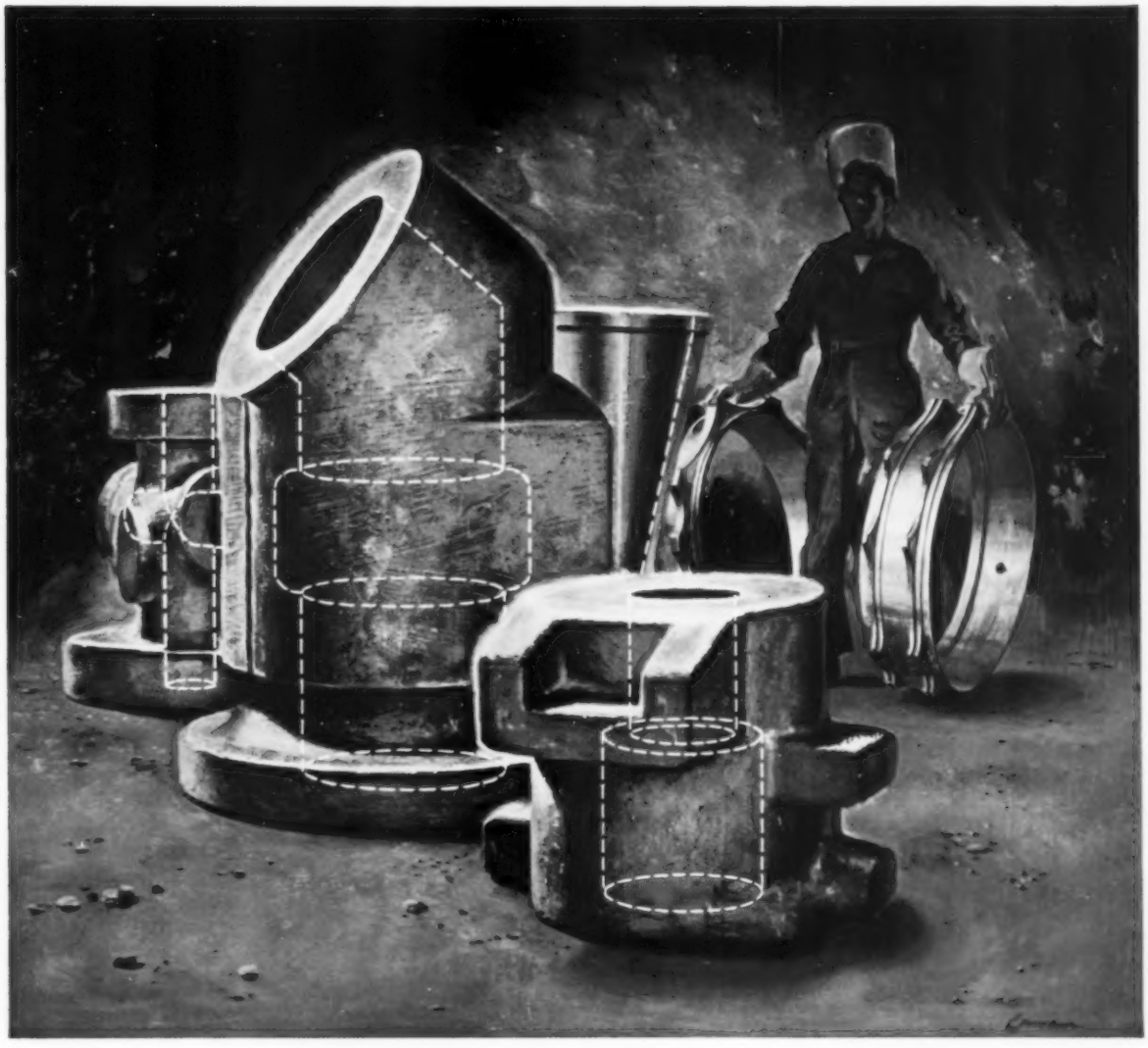
- *Cylindrical Roller Bearings*
- *Spherical Roller Bearings*
- *Tapered Roller Bearings* ("Tyson")

* Reg. U.S. Pat. Off. Tyson Bearing Corporation

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.



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* ferritic or austenitic

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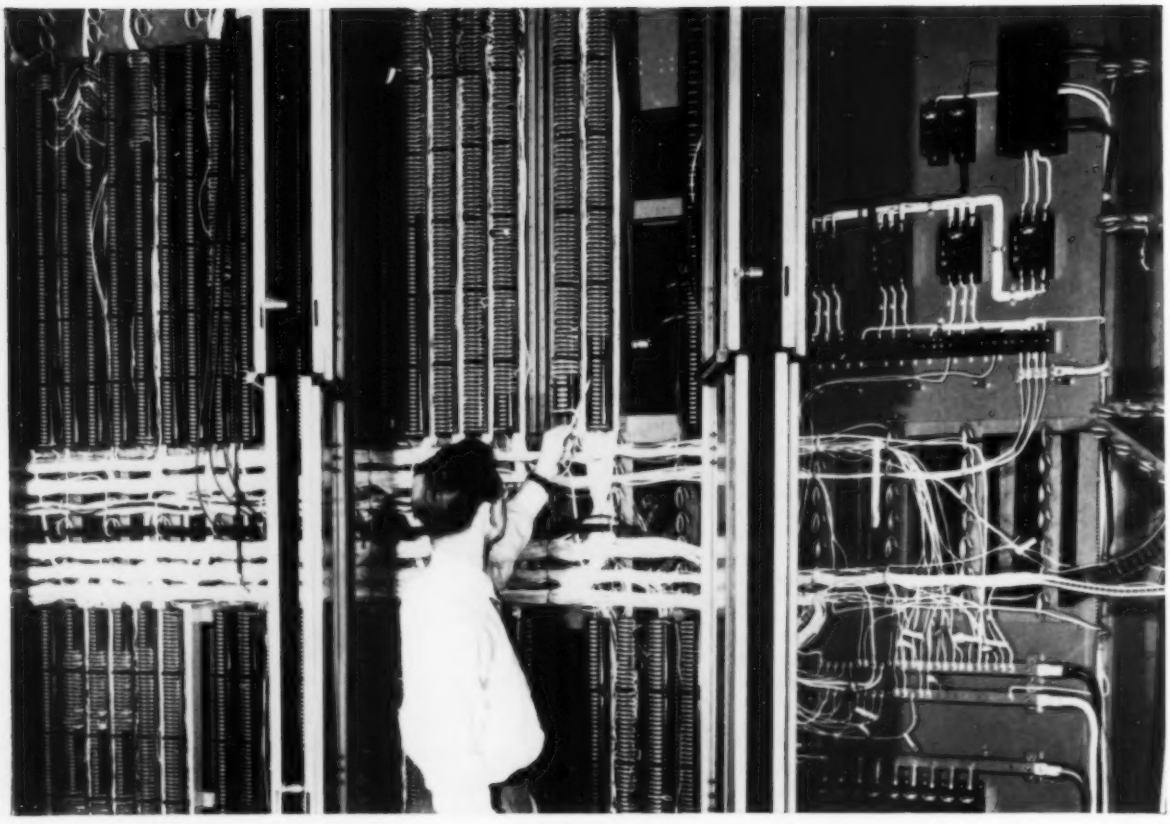

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Among all materials the phenolics are unmatched for combining dielectric strength with other properties — electrical, thermal, and mechanical — required by many of today's engineered products.

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Due to their dimensional stability, Durez plastics are specified with confidence by engineers and recommended by molders for close-tolerance components. Impact strength and heat resistance are added major advantages in a wide range of applications.

To help your molder assure the results you want at lowest cost, many types of Durez permit easy preforming and molding in automatic machines. Talk your problem over with him . . . or let us send you engineering data.

At your service is the experience and engineering service that have made Durez the most widely used phenolics.

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DESIGNING WITH ALUMINUM

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 4 CORROSION RESISTANCE

ALUMINUM ALLOYS RESIST ATTACK BY WIDE RANGE OF ENVIRONMENTS, MANY CHEMICAL COMPOUNDS

(THIS ADVERTISEMENT REPEATED IN RESPONSE TO THE HIGH INTEREST EXPRESSED BY ENGINEERS AND DESIGNERS.)

RESISTANCE to corrosion is a relative matter because it depends on the environment to which a metal is exposed. Aluminum and aluminum alloys have generally excellent corrosion resistance. They withstand corrosive attack by most types of environment, including many which adversely affect the performance of other commonly used metals.

Conditions which cause the corrosion of aluminum are the exception, not the rule. Normally, aluminum lasts indefinitely—bare and unprotected. This fortunate situation occasionally leads to over-enthusiastic use. The user may expect and demand a much higher level of performance from aluminum than he ever has or would from another metal, with resulting improper application or failure to follow good installation practice.

Reason for the good corrosion resistance of aluminum is that the practically transparent oxide coating that forms on surfaces exposed to air is tough, adherent and non-flaking. So, once formed, it is non-progressive and non-destructive, in contrast to oxidation which results in flaking that constantly exposes new metal to attack and so proceeds inevitably towards the total destruction of the metal.

Under most conditions the oxide coating of aluminum thickens within a relatively short time to a point where no further measurable oxidation occurs. It is also self-renewing. Whenever the oxide film is broken, it immediately reforms on exposure to air and again assumes its protective role.

It follows then that the conditions which promote the corrosion of aluminum usually involve the presence of a compound which dissolves or otherwise penetrates this coating, and the absence or exclusion of the oxygen required to rebuild it.

One of the useful properties connected with aluminum is that the electrolytic process known as anodizing thickens and strengthens the oxide coating artificially. Anodizing thus increases resistance to destructive atmospheres and also tends to reduce the possibility of galvanic corrosion. Anodizing is regular commercial practice in many applications and products of aluminum. A coincidental benefit resulting from this process is that brilliant color can be incorporated to obtain highly decorative effects, and frequently it is used for this purpose only. Building up the oxide coating also increases resistance to abrasion.

High purity aluminum is rated as having the best corrosion resistance to chemicals, but this is not always the case with other forms of attack. For instance, in marine atmospheres 52S is superior to high purity aluminum. Most aluminum alloys will generally outlast other metals except under special conditions.

ATMOSPHERIC CORROSION

In general service metals may be exposed to three types of atmosphere—normal (rural, uncontaminated), industrial (urban, contaminated) and marine (moist, salty).

Tests of several aluminum alloys sponsored by the American Society for Testing Materials (Table 1), using the percent change in tensile strength as a measure of corrosion resistance, showed that all the alloys exposed were practically unaffected by normal atmospheres. In industrial and marine atmospheres corrosion was so slight as to be of no significance in practice. This was true even for 24S-T3, copper-bearing heat-treatable alloy. The clad form of this alloy suffered no loss in tensile strength, indicating the effective protection given to the high-strength alloy core by the cladding of higher-purity aluminum.

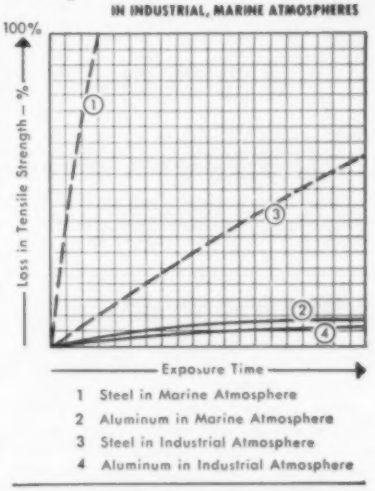
Table 1—EFFECT OF VARIOUS NATURAL ENVIRONMENTS ON ALUMINUM ALLOYS

(% Change in Tensile Strength Resulting from Ten Year Corrosion Tests Conducted by American Society for Testing Materials)

Alloy Type	MARINE			INDUSTRIAL		RURAL	
	La Jolla, California	Key West, Florida	Sandy Hook, New Jersey	New York, New York	Altoona, Pennsylvania	Phoenix, Arizona	State College, Pennsylvania
2S-H14	— 5	—2	—3	—7	—5	—1	—4
3S-H14	— 3	0	0	—4	—6	0	—1
24S-T3	—18	0	—3	—9	—6	—1	—4
Clad 24S-T3	+ 2	+1	+2	+2	0	+2	+1

NOTE: The gains in strength resulting in some cases arises from the fact that the tensile strength of heat-treatable alloys increases with natural aging.

Fig. 1—RELATIVE LOSS OF TENSILE STRENGTH IN INDUSTRIAL, MARINE ATMOSPHERES



1 Steel in Marine Atmosphere
2 Aluminum in Marine Atmosphere
3 Steel in Industrial Atmosphere
4 Aluminum in Industrial Atmosphere

Numerous other tests of aluminum alloys, both wrought and cast, have shown similar results, while steel simultaneously exposed has been virtually destroyed by industrial and marine atmospheres over a period of time. Typical relative loss in tensile strength of aluminum alloys and steel under exposure to marine and industrial atmospheres is illustrated in Figure 1. These test results are verified by the long actual service given by aluminum in buildings and equipment under severe conditions where other materials have required steady maintenance or replacement. A guide to the resistance of a number of aluminum alloys to atmospheric and sea water attack is given in Table 2.

Of importance as well is the fact that aluminum stands up well in contact with most other common building materials. Such attack as may occur is usually limited to superficial etching and minor pitting where dirt accumulates between faying surfaces. Although it has been considered good practice to protect the surface of aluminum where it is in contact with concrete or mortar, protection is really not necessary. Most if not all of any attack, even upon unprotected aluminum, takes place early during the setting period and is so minor as to be

PLEASE TURN TO NEXT PAGE ➡

of no consequence. Maximum penetration of the metal under such conditions probably would not be much over two mils. Where aluminum is in contact with masonry or wood which is continuously or repeatedly wet, it should be protected with a bitumen or similar coating on the contacting surface.

Table 2

RELATIVE CORROSION RESISTANCE OF ALUMINUM ALLOYS

Alloy	Non-Industrial Atmosphere	Industrial Atmosphere	Marine Atmosphere or Sea Water Service
1100	A	B	B
3003	A	B	B
3004	A	B	B
5005	A	A	A
5050	A	A	A
5052	A	A	A
5086	A	A	A
6061-T4 or T6	A	B	B
6063-T5	A	B	B
2024-T3	B	C	D
Alc. 2024-T3	A	A	B
7075-T6	B	C	D
Alc. 7075-T6	A	B	C
214, 218	A	A	A
43, 356-T6, 360	A	B	B
195-T4	B	C	D

A = Best relative resistance
B = Good relative resistance
C = Fair relative resistance
D = Not usually recommended without additional surface treatment

NOTE: This table is to be used as a general guide only, since in many applications an alloy with a D rating performs satisfactorily while in other applications an alloy with an A, B or C rating may require additional protection.

After prolonged exposure to normal air, aluminum surfaces weather, with some loss of the original polish and smoothness. This is seldom more than a superficial condition that can be remedied by simple cleaning.

AQUEOUS CORROSION

Most of the non-heat-treatable aluminum alloys and clad forms of the heat-treatable alloys offer a high order of resistance to corrosion by alternate immersion in sea and harbor waters, where unprotected steel deteriorates rapidly.

Magnesium-bearing alloys such as 50S and 52S are especially resistant to all forms of aqueous corrosion. 52S, strongest non-heat-treatable sheet and plate alloy in commercial use which is noted for its ruggedness, is used extensively in marine applications.

The copper and zinc-bearing heat-treatable alloys such as 14S, 24S and 75S are generally less resistant to aqueous attack, but their performance under salt water conditions is substantially improved by cladding. 61S has better resistance than the other heat-treatable alloys, and is therefore used widely in the bare condition.

CHEMICAL CORROSION

The chemical process industries are large users of aluminum because it resists attack by many chemical compounds. Aluminum in some instances offers the further advantage that the salts of aluminum are colorless, tasteless and non-toxic so that any corrosive products will not adversely affect manufactured products.

(Advertisement)

An example is the use of aluminum for the manufacture, storage and transportation of glacial acetic acid. There is no contamination, other impairment or coloring of the product by any products which might be introduced through superficial attack.

Table 3

PARTIAL GENERAL GUIDE TO RESISTANCE OF ALUMINUM TO VARIOUS COMPOUNDS

COMPOUND	GRADE
Acetic Acid, Dilute	B
Acetic Acid, Glacial	A
Alcohol, Methyl & Ethyl	B
Ammonia (dry)	A
Ammonium Hydroxide	C
Benzene	A
Boric Acid	A
Bromine	D
Carbonic Acid (dilute)	A
Chloride of Lime (calcium hypochlorite)	C
Chlorine (v.c. with water)	D
Creosote	B
Dichlorodifluoromethane (Freon F-12)	A
Dichloromonofluoromethane (Freon F-21)	B
Dichlorotetrafluoroethane (Freon F-114)	A
Ethylene Glycol	B
Fluorine	D
Freon 11	B
Freon 22	A
Freon 113	B
Gasoline (anhydrous)	A
Hydrochloric Acid	D
Hydrogen Peroxide (30% and higher)	A
Lacquers	A
Lime	B
Nitric Acid (above 80%)	A
Nitroglycerine	A
Olive Oil	A
Oxalic Acid	C
Oxygen	A
Perchlorethylene (dry)	A
Phosphoric Acid	D
Potassium Bicarbonate	A
Potassium Carbonate	C
Potassium Chromate	A
Resins	A
Sewage	A
Sodium Carbonate	C
Sodium Nitrate	A
Sodium Sulfate	B
Steam, Low Pressure	A
Sulfur Dioxide (dry)	A
Toluene	A
Trisodium Phosphate	C
Urea	A
Varnish Solvents	A
Water, Distilled	A
Water, Industrial	B
Water, Rain	A
Water, Sea	C
Water, Tap	C
Zinc Acetate (up to 10% conc.)	A
Zinc Chloride	D

NOTE: Resistance — A, excellent; B, good; C, fair; D, poor.

Aluminum provides excellent corrosion resistance to organic compounds and such chemicals as ammonia, hydrogen sulfide, hydrogen peroxide (30% and higher) and concentrated nitric acid. Solutions of strong alkalis, sulphuric acid, hydrochloric acid, carbonates and fluorides tend to attack aluminum because they can dissolve or penetrate the protective oxide coating. However, the extent of corrosion varies with concentration and temperature and may often be minimized or eliminated through the use of inhibitors. Table 3 provides a guide to the relative chemical resistance of aluminum to a few widely used compounds.

GALVANIC CORROSION

Direct contact with dissimilar metals in the presence of a liquid which might become an electrolyte should be avoided to prevent corrosion of the anodic metal. Metals such as zinc and magnesium are usually anodic to aluminum. It is not always true that aluminum is anodic to steel. For example, in some tap water conditions, particularly where higher temperatures are involved, steel may be attacked in preference to aluminum.

The danger of galvanic corrosion is frequently overrated. Its extent depends on the amount of current flow between dissimilar metals. In turn this depends on the electrical resistance of the space by which the metals are separated as well as the difference in potential.

In most cases galvanic corrosion can be entirely eliminated or reduced to negligible proportions by simple, practical methods. There can be no galvanic corrosion if moisture is excluded or if insulating material increases electrical resistance. The problem is minimized when the anodic area is large in comparison with the cathodic area such as a large area of aluminum and a small area of steel or copper. Innumerable composite steel and aluminum structures have given long life.

CORROSION PREVENTION

There are numerous ways of protecting aluminum where it is used under circumstances where conditions may be conducive to corrosion. They include painting, artificial thickening of the oxide film through anodizing, formation of other insoluble films, plating or cladding. Where used with aluminum, steel bolts and other fittings should be galvanized or plated with cadmium. Design should avoid corners and crevices where moisture can lodge.

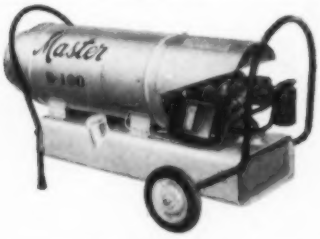
The assistance of Kaiser Aluminum engineers with information on the corrosion resistance of aluminum or on specific corrosion problems or other phases of aluminum application may be obtained by calling any Kaiser Aluminum sales office in the principal cities or by writing Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland, California.

Kaiser Aluminum

see our catalog in PRODUCT DESIGN FILE or write for copy

setting the pace . . . in growth, quality and service

Master B-100 Portable Space Heater
MANUFACTURED BY MASTER VIBRATOR COMPANY DAYTON, OHIO



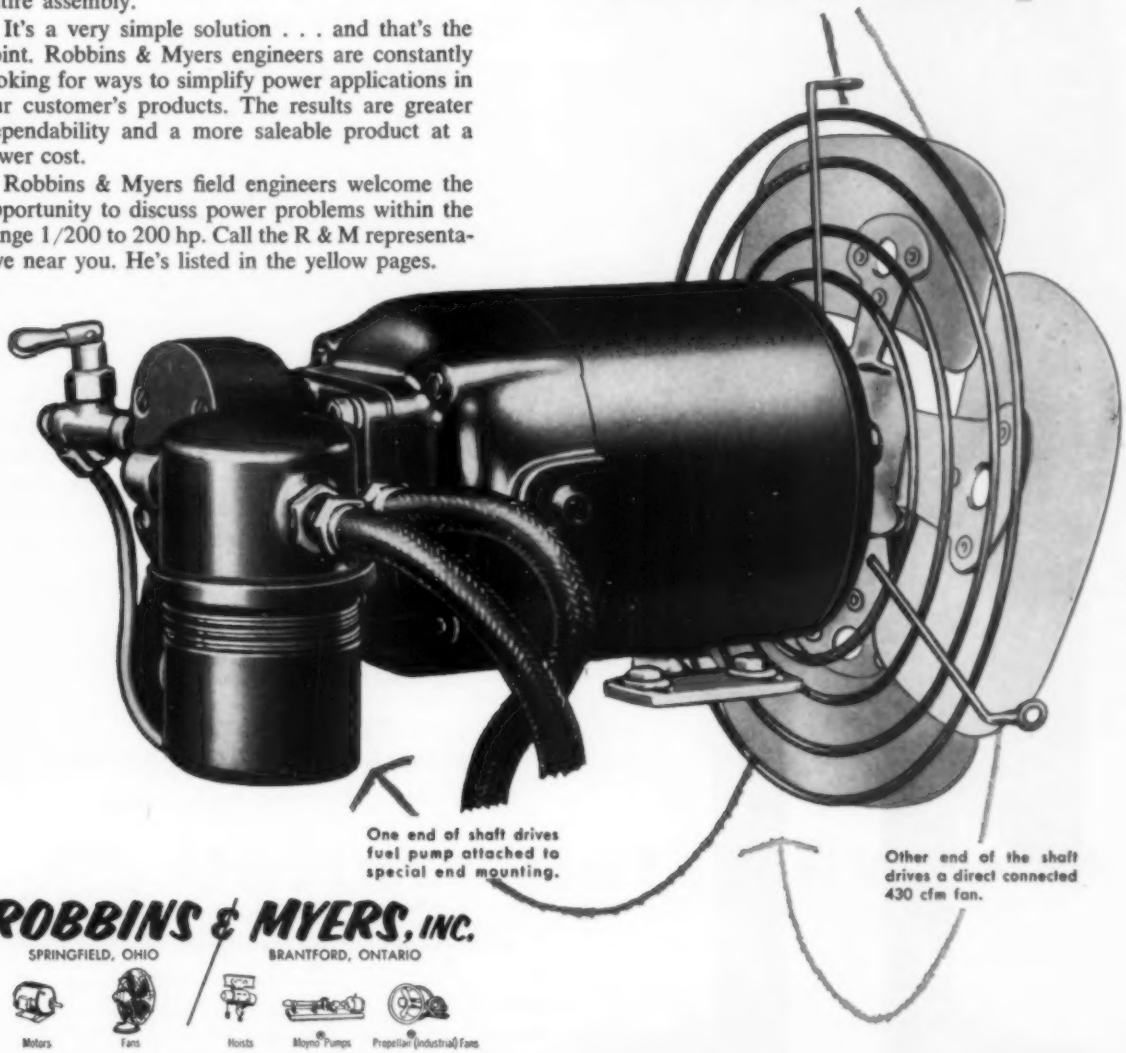
R&M motor does double duty

To accomplish compactness, simplicity and lower cost, this enclosed ¼ hp., 3450 rpm split phase Robbins & Myers motor was specially designed to do two important jobs in the Master B-100 Portable Space Heater.

A special face mounting accommodates a direct driven fuel pump. The other end of the shaft drives a direct connected fan with an output of 430 cfm. A rigid foot mounting on the motor supports the entire assembly.

It's a very simple solution . . . and that's the point. Robbins & Myers engineers are constantly looking for ways to simplify power applications in our customer's products. The results are greater dependability and a more saleable product at a lower cost.

Robbins & Myers field engineers welcome the opportunity to discuss power problems within the range 1/200 to 200 hp. Call the R & M representative near you. He's listed in the yellow pages.


One end of shaft drives fuel pump attached to special end mounting.
Other end of the shaft drives a direct connected 430 cfm fan.

ROBBINS & MYERS, INC.
SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

HOW

*. . . **Torrington** can make your small precision metal parts **faster, better** and **for less** than you can make them or buy them elsewhere*

These are typical of parts that Torrington produces daily by the hundreds or millions. If you use similar small precision parts, find out today how much you can save and the quality you can get by letting Torrington make them. Mail the coupon for the Torrington Small Precision Parts Condensed Catalog or to have a representative call. Even better, send a sketch, blueprint or sample part and we will give you a prompt quotation which will mean substantial savings to you.

THE TORRINGTON COMPANY • Specialties Division
230 Field Street, Torrington, Conn.

TORRINGTON
SPECIAL METAL PARTS
Makers of Torrington Needle Bearings

The Torrington Company — Specialties Division
230 Field Street, Torrington, Conn.

- ☐ Please send the Torrington Small Precision Parts Condensed Catalog.
- ☐ Please have representative call.
- ☐ Please send a quotation on enclosed sketch, blueprint, part.

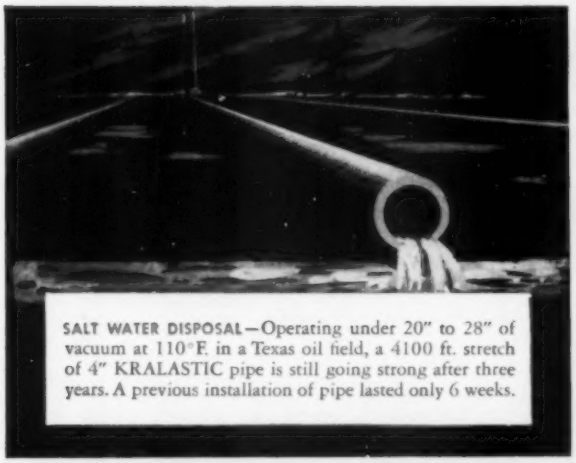
Name _____ Title _____

Company _____

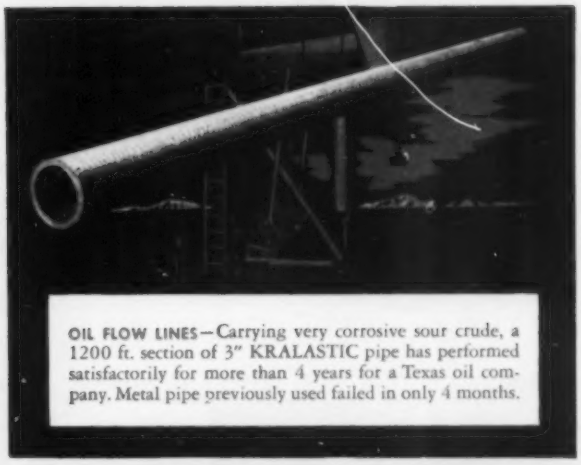
Address _____

City _____ Zone _____ State _____

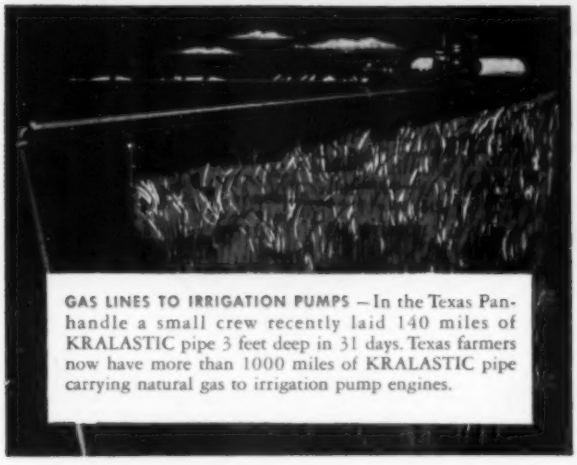
KRALASTIC Corrosion-Proof Pipe Makes Good in Many Fields!



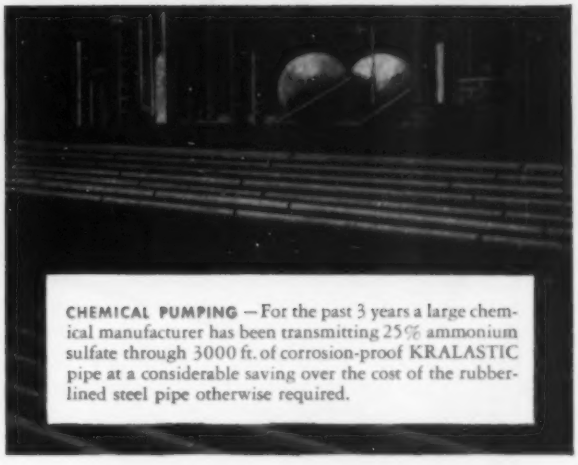
SALT WATER DISPOSAL—Operating under 20" to 28" of vacuum at 110°F. in a Texas oil field, a 4100 ft. stretch of 4" KRALASTIC pipe is still going strong after three years. A previous installation of pipe lasted only 6 weeks.



OIL FLOW LINES—Carrying very corrosive sour crude, a 1200 ft. section of 3" KRALASTIC pipe has performed satisfactorily for more than 4 years for a Texas oil company. Metal pipe previously used failed in only 4 months.



GAS LINES TO IRRIGATION PUMPS—In the Texas Panhandle a small crew recently laid 140 miles of KRALASTIC pipe 3 feet deep in 31 days. Texas farmers now have more than 1000 miles of KRALASTIC pipe carrying natural gas to irrigation pump engines.



CHEMICAL PUMPING—For the past 3 years a large chemical manufacturer has been transmitting 25% ammonium sulfate through 3000 ft. of corrosion-proof KRALASTIC pipe at a considerable saving over the cost of the rubber-lined steel pipe otherwise required.

KRALASTIC®, a unique combination of plastic and elastomeric materials, is different both in composition and physical properties from other materials used in the making of plastic pipe. It produces pipe—and many other plastic products—that are both hard and tough, low in weight, high in tensile strength and unaffected by most chemicals that corrode metals.

Pipe extruded of KRALASTIC has been approved by the National Sanitation Foundation for underground water transmission lines. Because of the inert nature of KRALASTIC, this pipe will not add taste or odor to drinking water and will not corrode and scale internally to cut down flow and pressure. For more information on KRALASTIC, write or phone us.

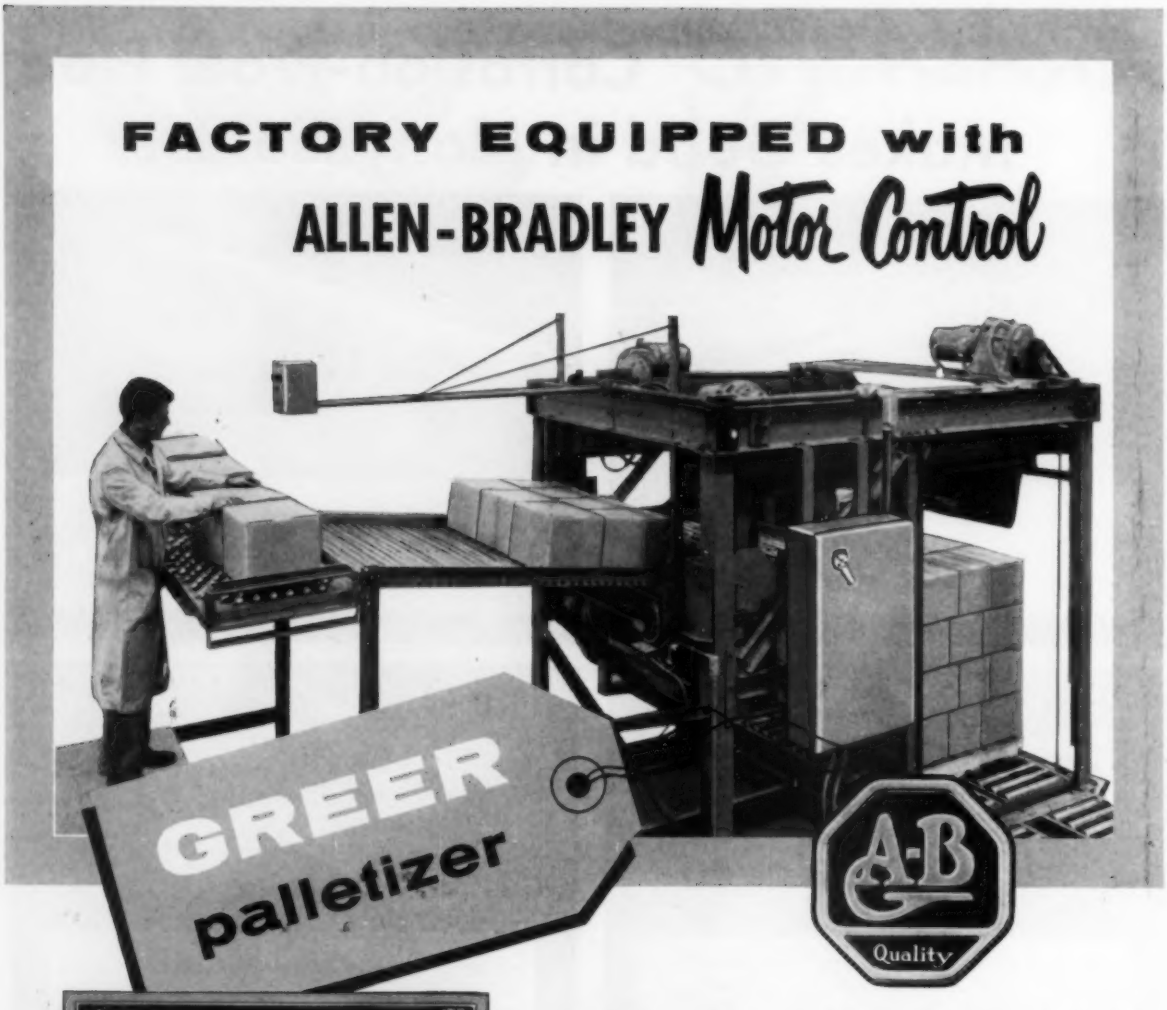
United States Rubber

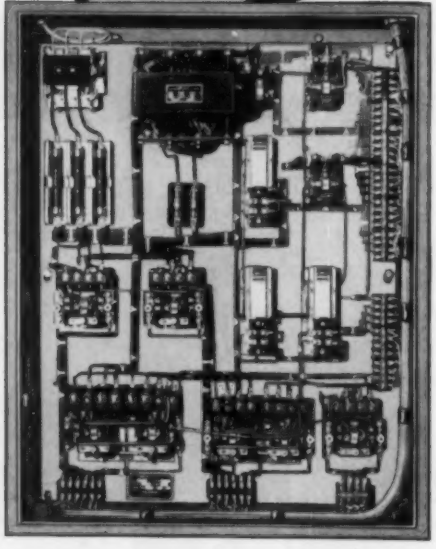
Naugatuck Chemical Division

Naugatuck, Connecticut

BRANCHES: Akron • Boston • Gastonia, N.C. • Chicago • Los Angeles • Memphis • New York • Philadelphia • IN CANADA: Naugatuck Chemicals, Elmira, Ontario
Rubber Chemicals • Synthetic Rubber • Plastics • Agricultural Chemicals • Reclaimed Rubber • Latices • Cable Address: Rubexport, N. Y.

FACTORY EQUIPPED with ALLEN-BRADLEY *Motor Control*





Special motor control panel for the Greer Palletizer containing standard Allen-Bradley control units listed in the Allen-Bradley Handy Catalog.

Complex production machinery will only pay dividends on the required investment where continuous production is assured. Reliable control apparatus is an important factor in such production. That's why Greer chose Allen-Bradley motor control for its pallet loader.

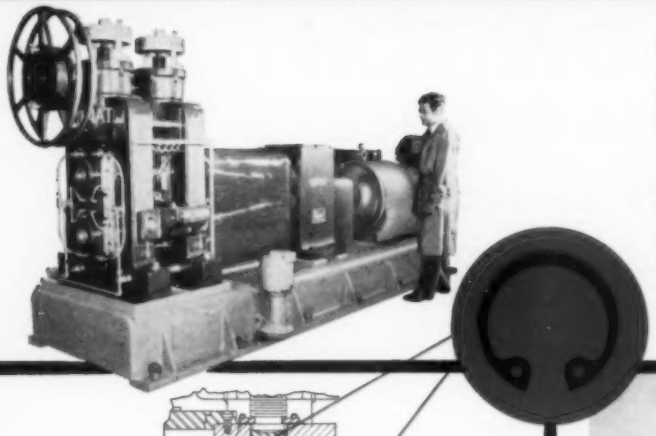
The double break, silver alloy contacts on Allen-Bradley control need no maintenance attention of any kind. They are always in top operating condition. And Allen-Bradley's simple solenoid mechanism—with only *one* moving part—is your guarantee of *millions* of trouble free operations.

You can install Allen-Bradley motor control and *forget it!* Try this "quality" control on your tough jobs.

Allen-Bradley Co.
1329 S. First St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

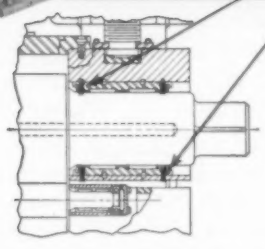
ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

7-inch Waldes Truarc retaining rings cut costs, speed assembly-disassembly of 2-high/4-high mill

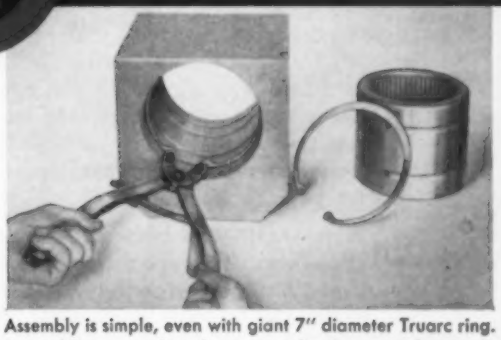


New Model TA-625 2-high/4-high combination rolling mill designed by Stanat Manufacturing Co., Long Island City, N. Y., reduces 2½" ingot to precision-rolled strip as thin as .001".

Waldes Truarc retaining rings help make possible a complete change of work rolls in 20 minutes...solve difficult problems of accuracy control by achieving positive location of bearings to extremely close tolerances. Rings eliminate costly parts and machining, save space, reduce maintenance.



In the assembly illustrated above, 7" Waldes Truarc (Series 5000) retaining rings—three on each roller—are used to position heavy-duty needle bearings in the bearing housing. Smaller rings position bearings in other roller assemblies and retain the shaft of a dual handwheel screwdown. All in all, 18 Waldes Truarc rings are used in the mill. They replace machined shoulders, spacers and lock nuts...eliminate costly threading, other machining operations.



Assembly is simple, even with giant 7" diameter Truarc ring. Special Truarc ratchet pliers grasp the ring securely, ease it into the groove, snap it securely into position. Smaller pliers and various high-speed assembly jigs are available for other rings, permit assembly-disassembly to be performed rapidly even by unskilled labor.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. Quick and easy to assemble and disassemble, they do a better job of holding parts together. Truarc rings are precision-engineered and precision-made, quality controlled from raw material to finished ring.

36 functionally different types...as many as 97 different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U.S.A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

WALDES TRUARC® RETAINING RINGS

©1956 Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N.Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L.I.C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name _____
Title _____
Company _____
Business Address _____
City _____ *Zone* _____ *State* _____

PN 029

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,252; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

MICRO SWITCH Precision

...FIRST IN PRECISION SWITCHING

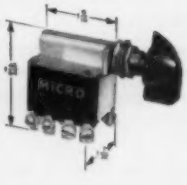
HOW MICRO SWITCH ENGINEERING SERVICE can keep a small switch from becoming a BIG PROBLEM in your design

MICRO SWITCH Engineering Service is a two-way street. Field engineers and factory engineers work together to make sure you get the right MICRO SWITCH precision switch for your application.

This teamwork between experienced switching specialists assures that the precision switches you incorporate in your equipment are the right switches for your application and will give reliable, dependable, day-in, day-out service.

You can take advantage of this teamwork by calling MICRO SWITCH today. Switching specialists—with close contact at the world's largest headquarters for precision switches—are available at branch offices in key cities.

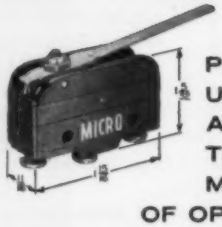
CONTROLS MANY CIRCUITS WITH ONE MANUAL MOTION



This three-position, rotary-type toggle switch offers all the advantages of a toggle switch mechanism with longer operating life and better detent "feel." Shown is a four-pole double-throw switch with 12 terminals. It is maintained in all three actuation positions, on-off-on. This switch can handle a high electrical load and has passed severe tests for impact, shock, acceleration and vibration.

(*Send for Data Sheet 112*)

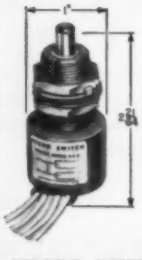
PRECISE, UNERRING ACTUATION THROUGH MILLIONS OF OPERATIONS



Adjustable lever actuator permits close adjustment of switch operating point without removal from mounting. It provides unusually reliable service on such equipment as timers, computers or other multiple-mounted devices which require precise, unerring operation through millions of operations. Available with normally open, normally closed double-throw or split-contact circuitry.

(*Send for Data Sheet 100*)

FOR PRECISE PERFORMANCE UNDER MOST EXTREME CONDITIONS



MICRO SWITCH "EN" switches are capable of reliable, long-life performance under extreme environmental conditions. They are completely sealed, cylindrical and can be mounted wherever a through hole can be provided. Variations of the "EN" are capable of actuation by almost any means. Available in choice of four different contact arrangements. Equal in performance to many switches twice the size.

Switches have uses unlimited

Switches put "THINK" into this press transfer feed

Here is a typical example of how a manufacturer improved his product. With MICRO SWITCH Precision Switches designed into the press, blanks are loaded and fed automatically, dangerous manual feeding is eliminated, mistakes are "erased" without interrupting production. This product improvement was due in no small measure to the help of MICRO SWITCH application engineers.

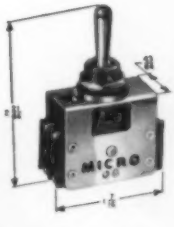
For more information for your design engineers, write for Catalog 83.

When a stack of blanks is nearly depleted, the descending elevator trips this switch which starts a motor and turns the six-station turret to the next full station for blanks.

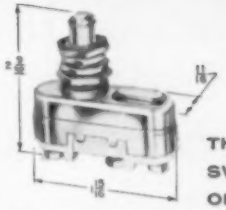
Plunger which picks up the blanks is controlled by switches shown. Upper switch stops the press if the blanks do not reach level of gripping fingers. Switch at left brings new stack of blanks into position. If stack doesn't come into position, the third switch stops press.

When two blanks stick together and feed into the press they trip this switch which actuates a solenoid and opens a trap door in the press bed. The blanks fall through, the press goes on uninterrupted.

SWITCH "REMEMBERS" CIRCUIT WHICH WAS LAST ACTUATED



This is the first of a new series of "electrical memory" toggle switches. The switch indicates through a pilot light or buzzer which circuit was last actuated. The assembly uses one pole of its four-pole circuitry to indicate which circuit was last operated. Use of this switch simplifies basic circuit designs of radar units, computers, aircraft control panels and other similar devices. Seal prevents entrance of liquids and dust. Basic switches are Underwriters' Listed at 5 amperes 125, 250 volts a-c, d-c rating at 28 volts-3 amperes at sea level, 2.5 amperes at 50,000 feet (inductive); 4 amperes at sea level and 50,000 feet (resistive); maximum inrush, 15 amperes.



THIS SWITCH OPERATES RELIABLY AT TEMPERATURES FROM −50° TO +1000° F

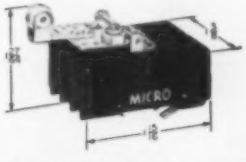
Use of laboratory-tested, heat-resistant materials makes this switch an extremely dependable component for use in applications where high temperatures are present. It will operate satisfactorily in a temperature range of −50° to 1000°F. Contact arrangements are single-pole double-throw. Switch is available in panel-mount design (shown) or with pin- or roller-plunger actuators.

(Send for Catalog 77)

A TWO-CIRCUIT SWITCH WITH ACCURATE REPEATABILITY

This switch uses a snap-action spring to provide quick make and break of both contacts in each double-break circuit. It is Underwriters' Listed for 10 amperes 125 or 250 volts a-c; ½ H.P. 125 volts a-c; 10 amperes 30 volts d-c.

(Send for Catalog 62)



TWO SWITCHES OPERATED BY A SINGLE LEVER ACTUATOR

This is an assembly of two single-pole double-throw switches. It provides for switching of two isolated circuits at the same time. The basic units are listed by Underwriters' Laboratories at 15 amperes 125, 250 or 460 volts a-c; ½ ampere 125 volts d-c; and ¼ ampere 250 volts d-c.

(Send for Data Sheet 100)

MICRO SWITCH, a Division of Honeywell, pioneered the manufacture and development of precision snap-action switches.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

MULTI-FLEX

A Versatile Line of Boots, Connectors, Bellows, Tubes, Air Ducts

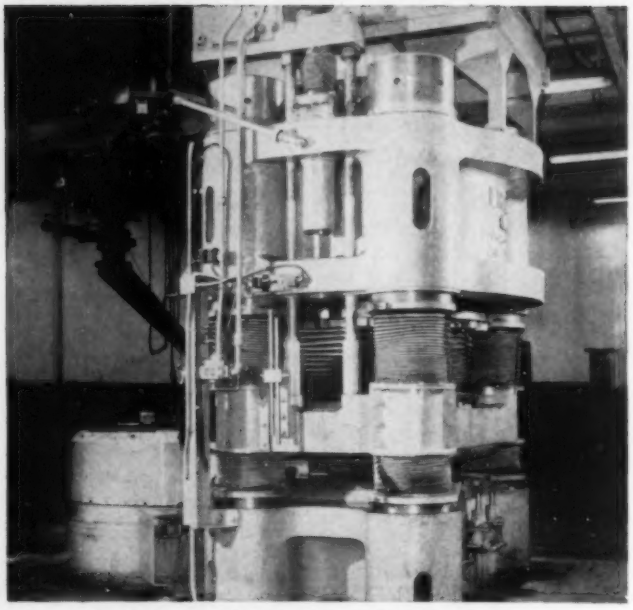
If the equipment you make requires

- accordion protective boots
- connectors to take bends or movements in compression or extension
- bellows to move air or be actuated by air
- extremely flexible tubing that will not kink

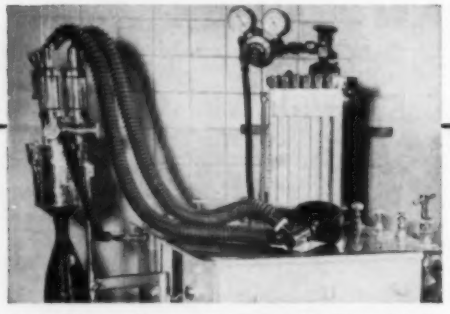
you'll do well to investigate U. S. Multi-Flex.®

Made circumferentially corrugated without molds or other tooling, in inside diameters ranging from ¼" to 48", and engineered to your particular requirements, these products may furnish the answer to difficult-to-solve application problems.

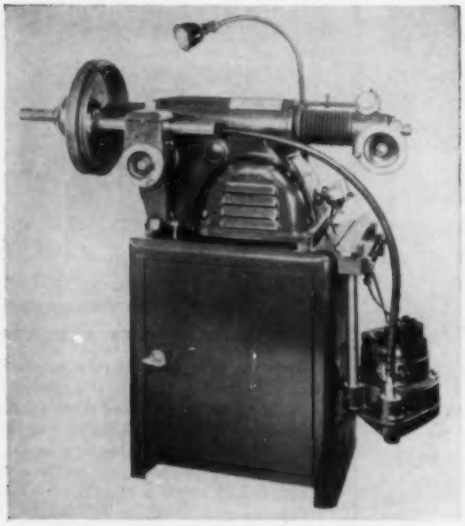
Get U.S. Multi-Flex, plus expert engineering service, at any of the 28 "U.S." District Sales Offices, at selected distributors, or by writing us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.



Multi-Flex laced boots keep dirt and grit out of hydraulic rams. They are laced for easy installation without dismantling press.



Multi-Flex conductive tube—extra-flexible and lightweight—in use on anesthesia equipment.



Multi-Flex boots giving constant protection to the shaft on this brake drum lathe.

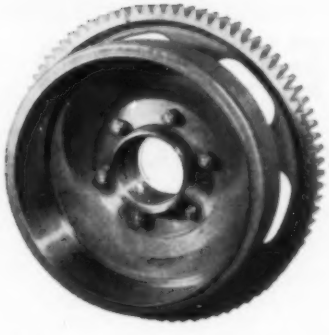
Multi-Flex connectors on vacuum filter, taking care of axial movement and misalignment.

Mechanical Goods Division

United States Rubber

On Link-Belt's new one yard shovel...

ELASTIC STOP® nuts remain tight under terrific shock loads



Elastic Stop nuts secure clutch drums to gears.

The engineering concept behind Link-Belt's new LS-98 Shovel-Crane provides a highly portable machine with big shovel characteristics plus stepped-up work cycles that produce substantial increases in capacity. To do this, the shovel-crane had to be built to stand up under heavy vibration and extreme shock loads. That's why Elastic Stop nuts were chosen for the critical fastening jobs throughout (i.e., hook rollers to brackets, clutch drums to gears, counterweight to upper frame, drum laggings to brake drums, engine mountings, side housing to revolving frame, etc.).

The locking principle of Elastic Stop nuts has been tested and proved by over 25 years of actual field service on equipment like this in every conceivable product of industry from locomotives to roller skates. What's special about this nut? For one thing, you can "stop" it at any position on the threaded length of the bolt . . . or wrench it tight against the work. No matter where you leave it on the bolt, it will remain tight in that exact position, even though you subject it to heavy vibration and shock loads. Reusable many times.

Elastic Stop nuts are available from a watchmaker's 0-80 all the way to 4"—in stainless steel, brass, aluminum and other alloys. Protect *your* product with "fastener insurance." We'll supply free test samples.

ESNA®

ELASTIC STOP NUT CORPORATION OF AMERICA

2330 Vauxhall Road, Union, N. J.

Elastic Stop Nut Corporation of America
Dept. N7-22, 2330 Vauxhall Road, Union, N. J.

Please send me the following free fastener information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

OZALID STREAMLINER 200

full-width whiteprinting for just $995.00!

Here's economical printmaking for every architectural office—*in full 42-inch widths!* Here's the brand-new Ozalid Streamliner 200—compact, low-cost table-model whiteprinter.

NEW CONVENIENCE
With Streamliner 200 in your office—you get prints whenever you need them—as soon as you need them.

ECONOMY!
In savings of drafting time alone, your Streamliner 200 quickly pays for itself. You make changes with *intermediates*—no costly re-drawings!

TOP QUALITY PRINTS, TOO
You get sharp, detailed prints—*in seconds.* Simple controls are easy to operate. Prints stack automatically. Compact design; only 22″ high, 27″ deep.

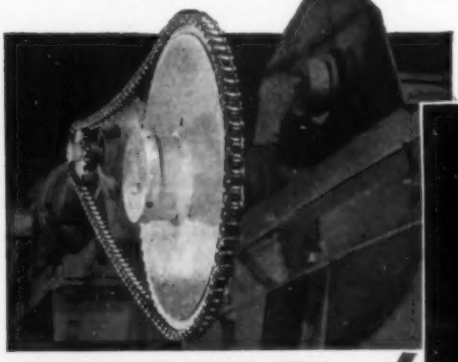
For all the facts on the Streamliner 200, call your local Ozalid representative. His number's in the phone book, or write: Ozalid, Dept. O-2, Johnson City, N. Y.

OZALID®

First name in whiteprinting

A Division of General Aniline & Film Corporation
In Canada: Hughes Owens Company, Ltd., Montreal

It's not just static strength...



RESISTANCE TO TENSILE STRESS is achieved by use of properly heat-treated, accurately-machined side bars made of premium steel and fitted with properly-hardened pins, bushings and rollers. But to resist *operational* stresses, additional controls over dimensional accuracy, uniformity and roller resiliency are essential.

STRENGTH OF CHAIN IN MOTION is accomplished through tensile strength *plus* special Link-Belt refinements. These include pitch-hole preparation, micro-finish of parts, special processing of sidebars, prelubrication and rigid quality control from initial selection of materials to final protective boxing.

it's *dynamic strength*

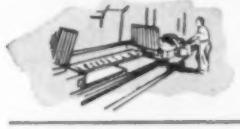
in LINK-BELT Roller Chain that fights fatigue

On high-speed, heavy-duty equipment, every roller chain component faces severe operating stresses — engagement with sprockets, shock of starting loads, centrifugal loads and others. That's why *dynamic strength*—ability of chain to resist these stresses—is so important. And it's built into *every length* of Link-Belt Precision Steel Roller Chain through special design, manufacturing and processing steps —providing required properties of uniformity and accuracy for long-life operation.

Let your Link-Belt office explain what dynamic strength can mean to the performance of your machine. And ask for Book 2457, covering this complete line of single and multiple widths, in ¼ to 3-inch standard pitch, 1 to 3-inch double pitch.

14.277

LINK-BELT gives you dynamic strength that comes from these important EXTRAS



PRE-STRESSING of multiple width chain provides uniform load distribution.

SHOT-PEENED ROLLERS have greater fatigue life, added ability to withstand impact.

LOCK-TYPE BUSHINGS (applied on a range of sizes) end a cause of stiff chain.

LINK-BELT

ROLLER CHAINS & SPROCKETS

Looking for the BEST chain and sprockets for a specific need? LINK-BELT makes the complete line

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World.

UNICHROME
Trade Mark

News about
COATINGS for METALS
Metallic . . . . . Organic . . . . . Decorative . . . . . Protective

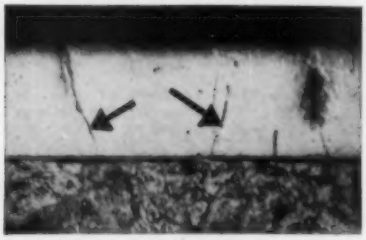
Plastisol coatings give protection "in depth"

Unique chromium plate gives solid corrosion protection

Deposits of Unichrome Crack-Free Chromium offer important advantages over ordinary chromium plate. They remain free from the cracks through which corrosives can penetrate ordinary chromium plate and attack the basis metal. (See photo below).

Crack-Free Chromium Plate therefore needs no nickel undercoat to stop corrosion. It offers a number of other features of interest to designers. These include:

Improved non-galling, non-seizing properties; superior resistance to thermal shock and impact. And, of course, wear resistance, hardness and low coefficient of friction. Send for Bulletin CFC-2.

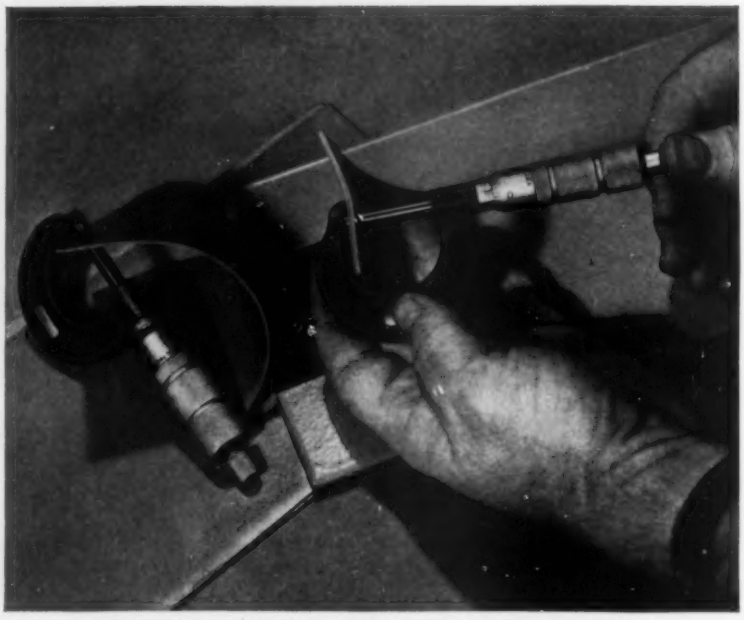


Cross section of etched ordinary chromium 0.00125" thick, unretouched. Note that some cracking extends to steel, opening the way for rusting. These flaws are absent in Unichrome Crack-Free Chromium.

Unichrome is a trademark of Metal & Thermit Corp.

METAL & THERMIT
CORPORATION

General Offices: Rahway, New Jersey
Pittsburgh • Atlanta • Detroit
East Chicago • Los Angeles
In Canada: Metal & Thermit—United Chromium of Canada, Limited, Rexdale, Ont.



Unichrome Plastisols provide single coat thicknesses approaching those of sheet materials. Thinner coats can also be applied as desired.

Vinyl plastisols form films with excellent resistance to chemical attack. But it's the *thickness* of resilient film buildup that really sets a plastisol coating apart from the usual coating . . . and makes ordinary metals coated with plastisols fit for heavy duty.

APPLICATION MADE EASY

Thickness of 60 mils or more per coat can be sprayed with Unichrome "Super 5300" Coating. Products dipped into Unichrome Series 4000 Coating can have a film thickness up to $\frac{3}{16}$ inch. Such body means *pore-free* protection, ample section to absorb damaging impact, and a *long-wearing* abrasion-resistant finish.

Many plants specializing in applying plastisols have enlarged facilities to handle bigger and bigger parts and products. Spraying or dipping is practical on *any* size product for which there are facilities to heat and hold the coated object at 350° to 365°F for curing.

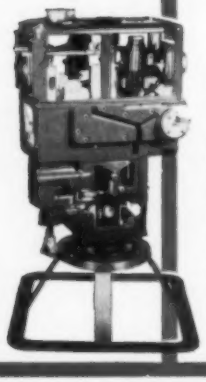
OTHER ADVANTAGES OFFERED

Plastisol coated products also get *seamless* protection against acids, alkalies, moisture, and other corrosives. The finish has satiny gloss, resists abrasion, deadens sound, insulates electrically, doesn't age and crack.

Record service has been delivered by Unichrome Plastisols on such diverse applications as pump impellers, dishwashing racks, agitators, ductwork, screens, cart bumpers, tool and work holders, plating racks, thumbtacks, enclosed tanks . . . to cite a few. Obviously, Unichrome Plastisols are versatile. Send for Bulletin VP-2 for more ideas.

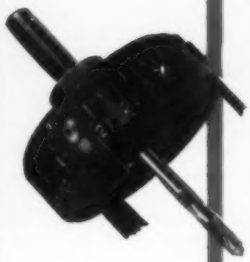
5 practical ways to "streamline"

...without sacrificing fastening strength

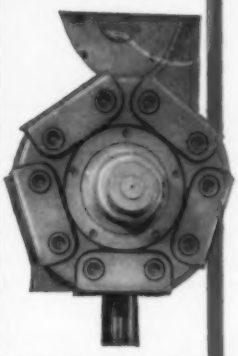


1. Counterbored holes are the simplest approach to flush surfaces using standard socket cap screws. The advantage of specifying genuine Allen O Head Cap Screws is the greater strength of Allenoy steel... you can use smaller sizes for closer spacing and reduced weight. Call on Allen, too, for *very large* socket-head, precision cap screws — up to 2½ inch diameter.

2. Countersinking enables you to get absolutely smooth external surfaces using Allen O Flat Head Cap Screws. Allen O Cap Screws feature the exclusive Leader Point which makes screw starting easier and guards against thread damage.



3. Button Head Cap Screws produce snag-free unbroken surfaces where countersinking is impractical. Button-head hex sockets are necessarily shallow. In genuine Allen O Button-Head Cap Screws, sockets are cold forged without broaching, in extra strength Allenoy steel... essential protection against stripping the sockets under high torque pressure.



4. A ready made hole tapped in forged steel solves many a design problem. It's called the Allenut. It can be anchored in soft material to assure durable threading, or recessed to permit tightening with an Allen Hex Key.

5. Bright finish, or rust and corrosion resistance call for Allen O Stainless Steel Cap Screws. They are standard stocked items (both NF & NC threads) readily available in a wide range of sizes from Allen Distributors.

YOUR ALLEN DISTRIBUTOR can give you practical help and swift service. For complete information on any technical fastening problem, write our engineering department direct.

ALLEN HEAD

ALLEN

MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

FEBRUARY
1957

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

DOW

HIGH SPEED MOLDING OF THIN WALL CONTAINERS

The high potential for molded packages today pinpoints the importance of automation. This requires special knowledge by engineers and designers. At Dow, continuing studies in Plastiatrics have been directed toward this dynamic industry's fast-growing concepts of design and manufacture.

To achieve the economy demanded of expendable containers, thin walls less than .030 inch are an economic necessity. The technological target of Plastiatrics research is the practical solution of difficult problems inherent in such injection molding.

Understanding of fundamental considerations, both in theory and in practice, is essential. Behavior of polystyrene materials throughout the molding system has been carefully documented at Dow. Photographic studies within the mold make it possible to anticipate, and hence, reduce areas of resistance, compression and stress. Orientation characteristics must be recognized to avoid directional loss of physical properties. Molding equipment and procedures must be selected with care to insure maximum possible output speeds. The refinement of injection molding principles, in sum, makes possible a scientific approach to the problems of automation. Better packages of higher quality will be the result.

Whatever the design, successful use of the finished product is the final test. To achieve the uniformity and high quality demanded by automation, the Styron® family of polystyrenes is carefully formulated and field tested. Plastiatrics is the scientific approach to the satisfactory application of plastics in the processes and uses required by competitive production engineering. Your nearest representative will be glad to furnish a summary of Dow products and services.

AUTOMATION OF THIS INJECTION MOLDING PRODUCTION LINE FOR VENDING MACHINE CUPS IS A MILESTONE IN THE DYNAMIC GROWTH OF PLASTICS MANUFACTURING.

WRITE FOR TECHNICAL BULLETIN

For a more detailed report on the molding of thin-walled containers, ask for Plastics Technical Service bulletin—"The Technology of Injection Molding, VIII, Thin Sections". Look for the findings of continuing Plastiatrics research in these pages regularly. THE DOW CHEMICAL COMPANY, Midland, Michigan . . . Plastics Sales Department PL 436G.

AMERICA'S FIRST FAMILY OF POLYSTYRENES

GENERAL PURPOSE
- STYRON 666
- STYRON 665 (Extrusion)
- STYRON 688 (Easy Flow)
- STYRON 689 (Easy Flow)

HIGH IMPACT
- STYRON 475
- STYRON 429 (Extrusion)
- STYRON 777 (Medium Impact)
- STYRON 440 (Heat Resistant)
- STYRON 480 (Extra High Impact)

HEAT RESISTANT
- STYRON 683
- STYRON 700

YOU CAN DEPEND ON DOW

Giant LeTourneau Sno-Freighter built on rugged backbone of SHELBY SEAMLESS MECHANICAL TUBING

Another LeTourneau "train," also constructed with Shelby Seamless Mechanical Tubing, maneuvers through the streets of Longview, Texas. The uncovered control car reveals its 3,500-gallon fuel tank and its two diesel engines which generate electricity for driving the wheel motors.

Sno-Freighter in action in northern Alaska. The control cab is 17 feet high; the decks of the cargo carriers are 8½ feet high. Speeds range from 0 to 15 MPH.

The LeTourneau Sno-Freighter is a huge six-section cargo carrier specifically designed to travel over ice, frozen or compacted snow, bull-dozed trails, or rough brush land. It is presently in active use hauling fuel and other strategic materials to radar stations along the Arctic Coast.

The Sno-Freighter "train" consists of a power control car and five cargo cars, each with a capacity of 25 tons. Two 400 H.P. diesel-electric generating sets on the power control car supply electrical power to the 24 drive wheels, each of which has a powerful electric motor tucked into its rim. Thus, each wheel drives independently of the others, making it practically impossible for the carriers to get stuck in sand, snow, or swamp.

All of the Sno-Freighter's car frames are constructed of Shelby Seamless Mechanical Tubing in diameters from 2 inches to 8 inches. In addition, each of the cars is coupled to the one preceding it through a universal joint and a long steel tube of Shelby Seamless. This constitutes the steering mechanism, causing each vehicle automatically to track the car ahead of it. The operator of the Sno-Freighter steers only the two front wheels of the power control car.

There are many good reasons why Shelby Seamless Mechanical Tubing was chosen for the supporting framework of this magnificent mechanical marvel. Primarily, it offers the ultimate in strength and rigidity in proportion to its size and weight. Secondly, it is shock-absorbent, uniform throughout, dimensionally accurate, and possesses excellent machining and superior welding properties. It is produced under rigid standards, and is available in a generous range of diameters, wall thicknesses, various shapes and steel analyses. And it can be fitted to your specifications, regardless of what they are. Contact our engineers. They will be happy to help you adapt Shelby Seamless to your requirements.

NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)

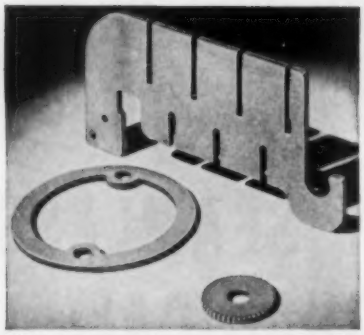
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

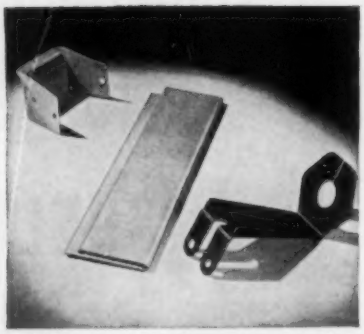
SHELBY SEAMLESS MECHANICAL TUBING

WELDS WITHOUT WELDS

UNITED STATES STEEL



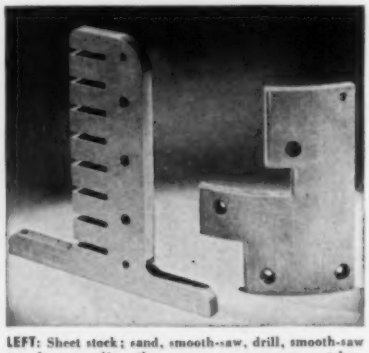
LEFT: Sheet stock; shear strips and punch. **TOP:** Sheet stock; shear strips, punch blank, gang-saw notches. **BOTTOM:** Sheet stock; shear strips, punch blank, mill notches.



TOP LEFT: Sheet stock; shear strips, punch, form. **CENTER:** Sheet stock; shear to size, drill, form. **BOTTOM RIGHT:** Sheet stock; shear strips, punch pieces, form twice in mold, rubber-stamp twice.

LOWER LEFT: Hexagonal rod; smooth-saw, automatic screw machine, turn shoulder thread, chamfer, and cut off. The other samples are automatic-screw-machine parts made from Diamond Fibre by C-D-F.

LEFT: Sheet stock; sand, smooth-saw to size, smooth-saw bevel, smooth-saw corner cut-out, drill. **CENTER:** Sheet stock; band-saw, turn OD, bore ID, smooth-saw side, drill five blind holes with jig. **RIGHT:** Sheet stock; sand, band-saw, rough-bore ID, hob teeth, finish-bore ID, machine keyway.



LEFT: Sheet stock; sand, smooth-saw, drill, smooth-saw to shape, radius three corners, gang-saw notches. **RIGHT:** Sheet stock; band-saw rough blanks; form; smooth-saw width, length, and shape; radius edges; drill with jig; countersink.

LOWER LEFT: Tube stock; automatic screw machine, turn shoulders, chamfer and thread end, thread other end. **UPPER LEFT:** Tube (two diameters); smooth-saw, tap, screw-machine larger piece; screw-machine, thread, knurl, chamfer, cut off small piece. **UPPER RIGHT:** Tube; smooth-saw to length, punch twice, countersink. **LOWER RIGHT:** Tube; screw-machine, chamfer, cut off, punch.

C-D-F fabricates and forms DIAMOND VULCANIZED FIBRE

FAST . . . AT LOW COST . . . DEPENDABLY

Vulcanized Fibre is a wonderful material if you know where to use it and how to buy it. We suggest on many jobs that it's best to do the fabrication and forming in C-D-F's shops. Why? Because C-D-F knows how. Since 1895 the company has put fibre to work in everything from buggy axle bushings to metal clad radio parts. The handling of thousands of set-ups for high speed, low cost production runs gives C-D-F an "experience bank" to draw from. Shop supervisors have a wealth of short cuts, little tricks that result in lower prices for you. They know the material and its peculiarities.

TOUGH, RESILIENT, STRONG

How long has it been since you examined the unique properties and wide range of C-D-F fibre grades? Vulcanized Fibre is arc resistant, mechanically strong, non-corroding, half the weight of aluminum. Repeated moistening and drying in forming insignificantly alters the nature, structure or quality of the fibre.

Since C-D-F has their own paper mill, uniform, quality control is made possible. Special grades are more easily developed. A good example is C-D-F Abrasive Fibre, a medium density fibre with excellent resin and grit adhesion, now widely used for abrasive discs.

A BIG, RELIABLE SOURCE

C-D-F does business with the largest tonnage users of sheet, rod and tube fibre in the world. This means good deliveries, good prices, reliable products for every new customer. You deal with a materials engineer, a C-D-F man who knows how to give you the most value in Diamond Vulcanized Fibre. If you want to improve design, simplify purchasing, speed production, use Diamond Fibre and the facilities of C-D-F. Write for catalog, free test samples, or send us your print for quotation.

CDF

CONTINENTAL DIAMOND FIBRE

CONTINENTAL-DIAMOND FIBRE DIVISION OF THE BUDD COMPANY, INC.

NEWARK 40, DELAWARE

The ring of quality

Colorful, low-cost sidewall rings that can be quickly installed on tires are now contributing to the luxury-look of today's new cars. They're inexpensive, stay brilliant for life, wash bright in seconds, out-last tires. A product of The Bearfoot Sole Co., Wadsworth, Ohio, these rings are available in a variety of colors or in white. They're made of Enjay Butyl Rubber because no other rubber tested could equal its performance in severe laboratory and road tests. The Enjay Butyl label on the Flex-A-Wall® carton assures the buyer of outstanding quality.

Find out for yourself the many technical advantages of Enjay Butyl—the rubber that is outperforming natural and other types of rubber in a wide variety of industrial and consumer applications. For full information, and for technical assistance in the use of Enjay Butyl, write, wire or phone the Enjay Company.

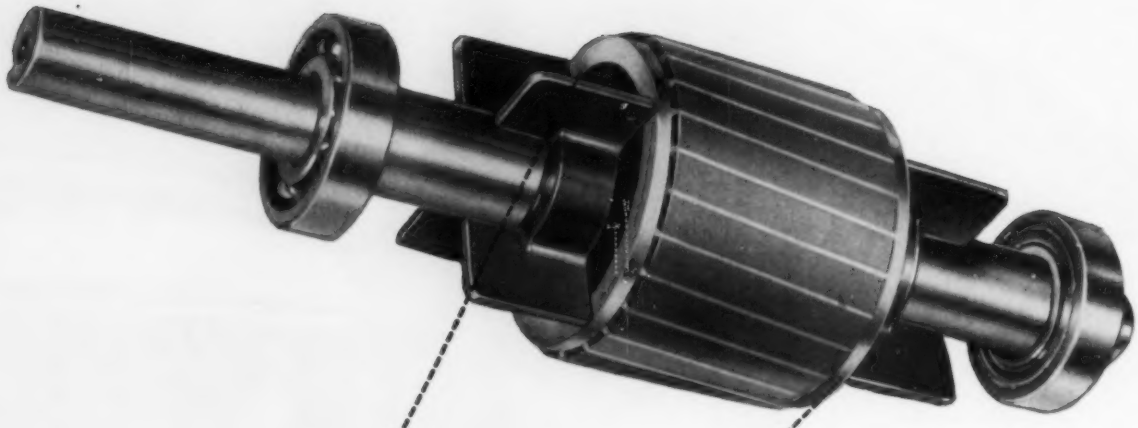
ENJAY BUTYL

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Other offices: Akron • Boston • Chicago • Los Angeles • Tulsa

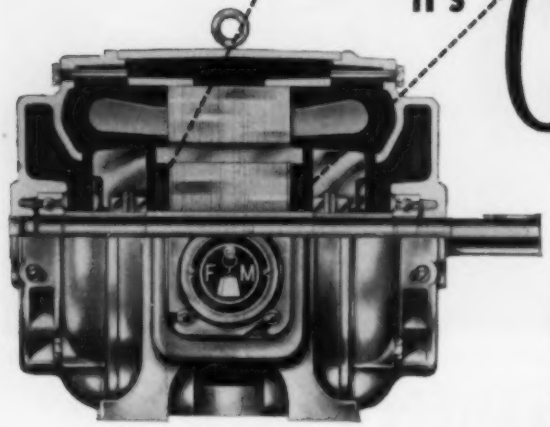
Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.



When you want motor performance

You want this Rotor design...

it's Copperspun



Long life, stamina and high efficiency—made possible by the Copperspun rotor found only in Fairbanks-Morse polyphase squirrel-cage induction motors.

Before specifying motors for sustained, heavy-duty drives, compare designs of the all-important rotor.

Fairbanks-Morse Copperspun rotors have the mechanical strength and the superior electrical and thermal characteristics of copper. Compare these advantages against aluminum or white metal alloys. Exclusive F-M method of centrifugal casting produces a truly one-piece rotor that is homogeneous, free from flaws and gas inclusions—virtually indestructible. It is accurately machined and dynamically balanced for longest trouble-free service on the toughest application.

The Copperspun rotor and the Fairbanks-Morse standard of quality manufacture make it more than worth your while to get in touch with the motor specialist from Fairbanks, Morse & Co., Dept. PE-2, Chicago 5, Ill.

FAIRBANKS-MORSE

a name worth remembering when you want the BEST

ELECTRIC MOTORS AND GENERATORS • DIESEL LOCOMOTIVES AND ENGINES • PUMPS • SCALES • RAIL CARS • HOME WATER SERVICE EQUIPMENT • MOWERS • MAGNETOS

LONGER SOLENOID LIFE...

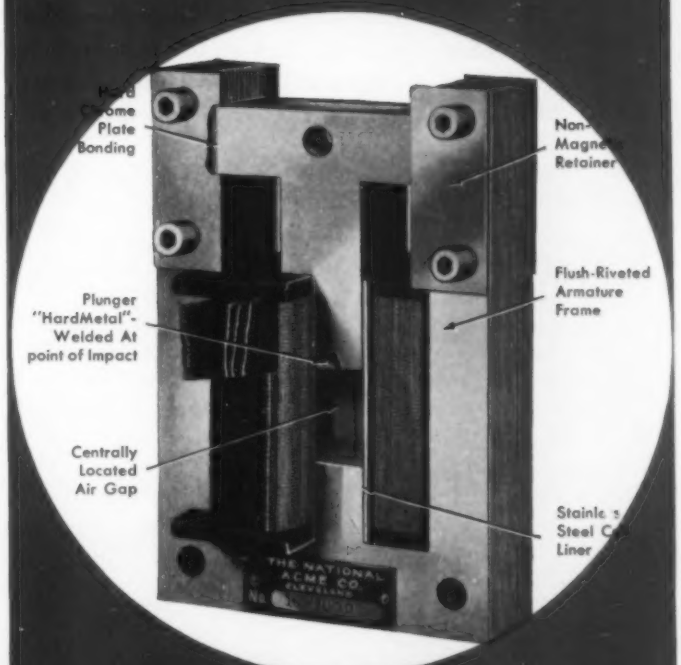
with NAMCO'S exclusive "HARDMETAL"-welded plunger bonding

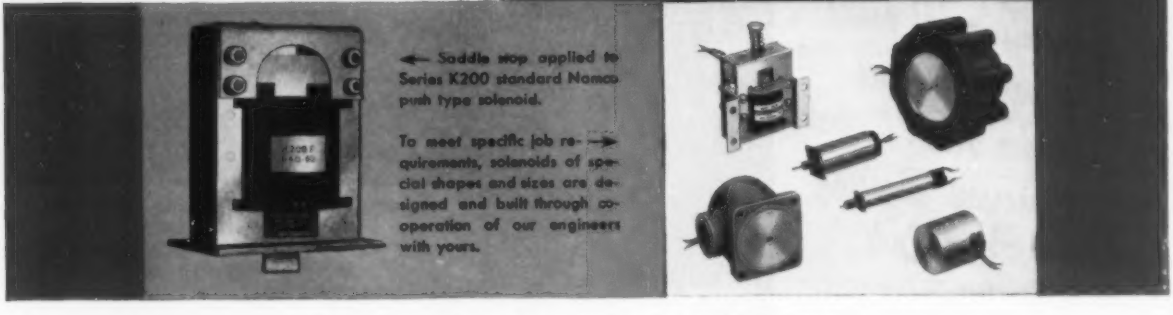
Standard or Custom Models To Fit Your Design

"HardMetal"-welded plunger bonding prevents mushrooming at the vital point of impact—withstands incessant pounding of the plunger on the frame. Long plunger life, and thus long solenoid life, is further insured by hard chrome plating upper guide edges of plunger laminations to reduce friction and wear.

Namco standard solenoids are available in six series of pull and push types; custom-engineered solenoids in every size and type can be made to meet your specifications.

Standard "HardMetal"-Welded Solenoids are furnished push or pull type in sizes with ratings from 2-1/2 to 21 pounds at 1/2" stroke and from 2 to 25 pounds at 1" stroke.





← Saddle stop applied to Series K200 standard Namco push type solenoid.

To meet specific job requirements, solenoids of special shapes and sizes are designed and built through cooperation of our engineers with yours. →

Ask us to send a National Acme Representative to discuss your problems, or if you want more information first—send for BULLETIN EM-52.

ELECTRICAL MANUFACTURING DIVISION

National Acme

THE NATIONAL ACME COMPANY • 170 EAST 131ST STREET • CLEVELAND 8, OHIO

Simplification and Improvement

HEIM *Unibal* ROD ENDS

Make it possible to reduce the number of component parts formerly used in the link-type parallel and the thread cutter mechanisms on Draper looms. The result of this simplification has been an improvement in the overall operation of the loom.

What is the Heim Unibal?

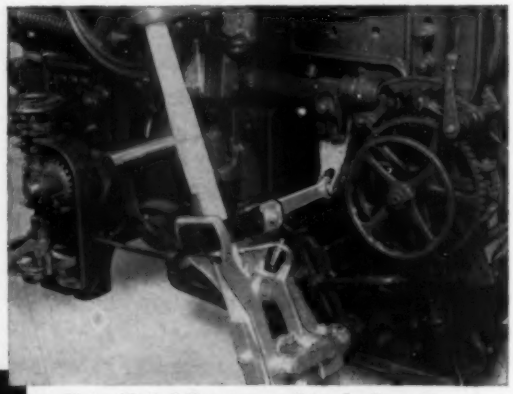
The outer member can be male (for attaching to a tubular rod), female (for attaching to solid rod stock), or a special shape to fit in with a particular design — but there is only one ball, and it rotates in bronze bearing inserts to correct misalignment in every direction. This Unibal construction provides a large surface supporting area to carry heavier loads. Here is a stock part, made in a wide range of sizes, which can take the place of a specially made assembly and perform better and smoother.

For the transmission of power at varying angles, consider Heim Unibal Spherical Bearing Rod Ends

Write for the Heim catalog.

Ask for any engineering aid.

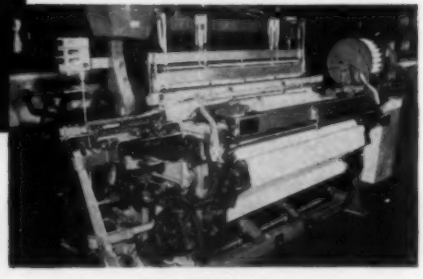
Heim Unibal Rod End



Heim Unibal Bearing used in the lug strap connector in the pick motion.

A pair of ¼" Unibal units are used in the thread cutter mechanism.

Four Heim female rod ends are used in the start-stop shipper linkage.



Draper X-2 Model loom

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

DU PONT

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA ON THESE VERSATILE ENGINEERING MATERIALS: "ZYTEL," "ALATHON," "TEFLON," "LUCITE."

Dial faces of LUCITE® molded with integral hairline cut production costs

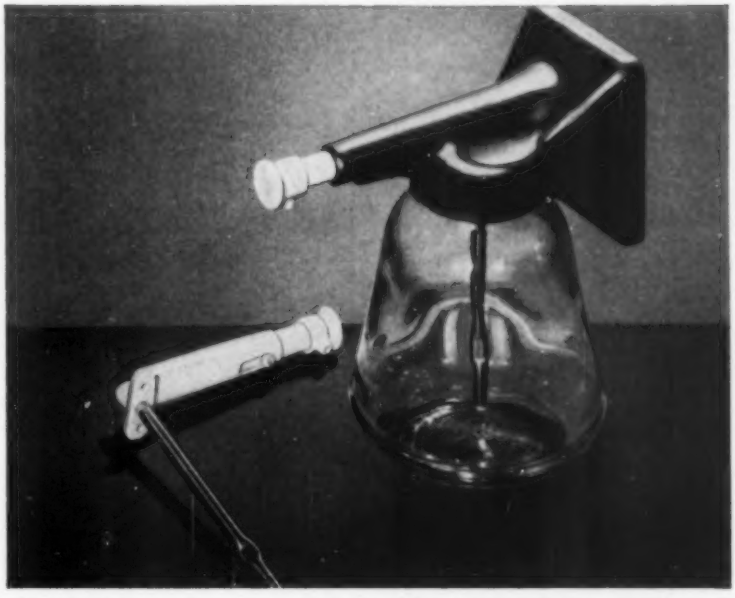
The precision with which Du Pont LUCITE acrylic resin can be fabricated is demonstrated by this hairline molded into one surface of a potentiometer dial face. The hairline is a half-round recess transferred directly from the die. The dial face replaces an assembly having a soldered wire hairline and a glass window, at a saving of $1.80 per unit. The parts made of LUCITE are economical to fabricate and withstand shock.

LUCITE offers outstanding transparency, transmitting about 92% of impinging light. LUCITE also has the ability to "pipe" light. In this instance, the clear LUCITE of the dial face transmits the "darkness" of the encasing black panel to the hairline, so that it is unnecessary to fill the hairline with black paint. The dial faces have been in service for more than two years with satisfactory results.

LUCITE is available in a wide range of sparkling, non-fading colors. It is shatterproof, light in weight, and resistant to weathering and many chemicals. LUCITE is fabricated economically by injection- or compression-molding, or extrusion. Du Pont LUCITE may be able to solve a design problem for you, particularly where high-grade optical qualities are required. Clip the coupon for more information about LUCITE acrylic resin.

This portable potentiometer, employed as a millivolt indicator, is manufactured by Leeds & Northrup Company, Philadelphia, Pennsylvania. Inset shows dial face of Du Pont LUCITE acrylic resin used in the instrument.

Precision molded parts of ZYTEL® can eliminate costly machining operations



"Likwidurn" soap dispenser manufactured by American Dispenser Company, Inc., New York, New York. Replacement of stainless-steel parts in valve assembly with parts of ZYTEL nylon resin afford substantial cost reductions.

Parts of ZYTEL nylon resin feature a high degree of durability, a low coefficient of friction, and good chemical resistance. Products molded of Du Pont ZYTEL are tough and strong, even in thin sections. They have excellent form stability at temperatures as high as 250°F. Cost savings are possible in many applications because components of ZYTEL usually require no secondary finishing. Frequently, a single part molded of Du Pont ZYTEL can replace an entire complex assembly.

The "Likwidurn" soap dispenser, shown above, is designed to deliver a measured amount of liquid soap at each stroke of the valve. Accurate fit of the valve parts is essential to assure proper operation. The valve must also remain unaffected by the concentrated soap solution.

ZYTEL nylon resin was chosen for this application, because it is economical to mass-produce parts injection-molded to close tolerances, which need no further finishing. The use of ZYTEL eliminates machining of the stainless steel, effecting substantial savings in manufacturing costs. In addition, the weight of the unit is reduced.

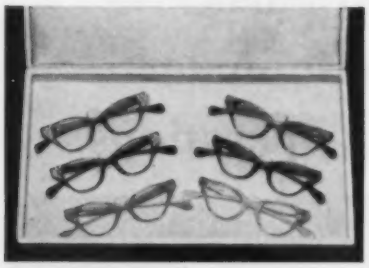
Evaluate ZYTEL in terms of your own design needs. Property and application data are available without obligation.

OVER

DU PONT

PRODUCT ENGINEERING NEWS

PROPERTY AND APPLICATION DATA
ON THESE VERSATILE ENGINEERING MATERIALS:
"ZYTEL," "ALATHON," "TEFLON," "LUCITE."

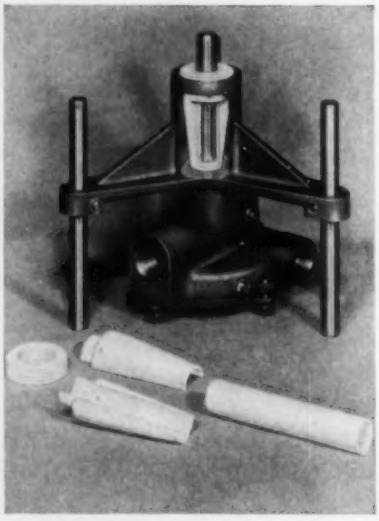


NYLAIRE — frames of ZYTEL® feature exceptional strength . . . attractiveness

Styled eyeglass frames of ZYTEL nylon resin withstand hard usage without breaking, combine attractive design with durability. ZYTEL can be molded in colors, so frames are offered in a selection of 34 permanent shades.

Fashion-conscious purchasers are pleased by smoothness, resiliency, and light weight of ZYTEL. Du Pont ZYTEL is distinguished by its toughness, form stability, and chemical resistance. These eyeglass frames are one interesting application of ZYTEL, which utilizes a number of the properties of this versatile engineering material. The use of ZYTEL may solve a design problem for you. (*Nylaire* eyeglass frames are manufactured by *Limited Editions, Inc., Linden, New Jersey.*)

High-speed bearing of TEFLON® resists corrosive attack, needs no lubrication



Cutaway portion of submersible pump shows bearing assembly of durable TEFLON tetrafluoroethylene resin. Assembly consists of shaft sleeve, tapered bearing, and lock nut. (The pump shown above is manufactured by ECO Engineering Company, Newark, New Jersey.)

A new bearing assembly of TEFLON tetrafluoroethylene resin has greatly broadened the range of applications of this chemical sump pump.

Due to the inherent surface "slipperiness" of TEFLON (kinetic coefficient of friction of only .04), no auxiliary lubrication of the bearing is necessary. Contamination of pharmaceuticals and sensitive materials by contact with lubricants is therefore prevented.

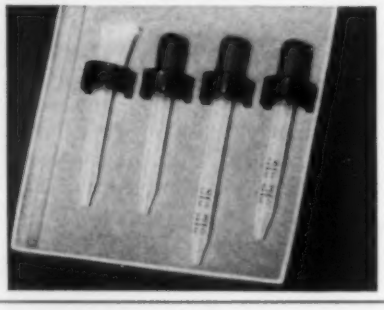
TEFLON is tough and durable. This permits the pump bearing to withstand high radial and tangential stresses at speeds of 3,540 rpm or higher for extended periods of time. The bearing is capable of continuous operation in the presence of product suspensoids and foreign abrasive matter such as tank scale. Bearings of TEFLON permit either chemical or steam sterilization.

Du Pont TEFLON tetrafluoroethylene resin has outstanding chemical inertness. This engineering material is not affected by aqua regia or other acids. Alkalies in any concentration do not react with it. TEFLON is inert to nearly all chemicals and solvents normally used in commercial practice. Exceptions to this include attack by the alkali metals under certain conditions. At elevated temperatures and pressures, halogens and certain halogenated chemicals and solvents may affect TEFLON.

Du Pont TEFLON offers a distinctive combination of mechanical, electrical, and chemical properties. Use of TEFLON has frequently resulted in more efficient, economical, and compact designs. In your applications, too, TEFLON may be the means of economizing on materials and costs or solving a tough design problem. For more details on how TEFLON can help you, clip and mail this coupon.

DROPPERS ARE UNBREAKABLE

Medicine droppers with unbreakable pipettes made of ALATHON® polyethylene resin give a regulated-size droplet. Lines can be printed on the pipette to indicate dosage. Smooth, highly transparent ALATHON reduces danger of injury to delicate tissues from accidental movements. (Made by PharmaPlastics, Inc., Baltimore, Maryland.)



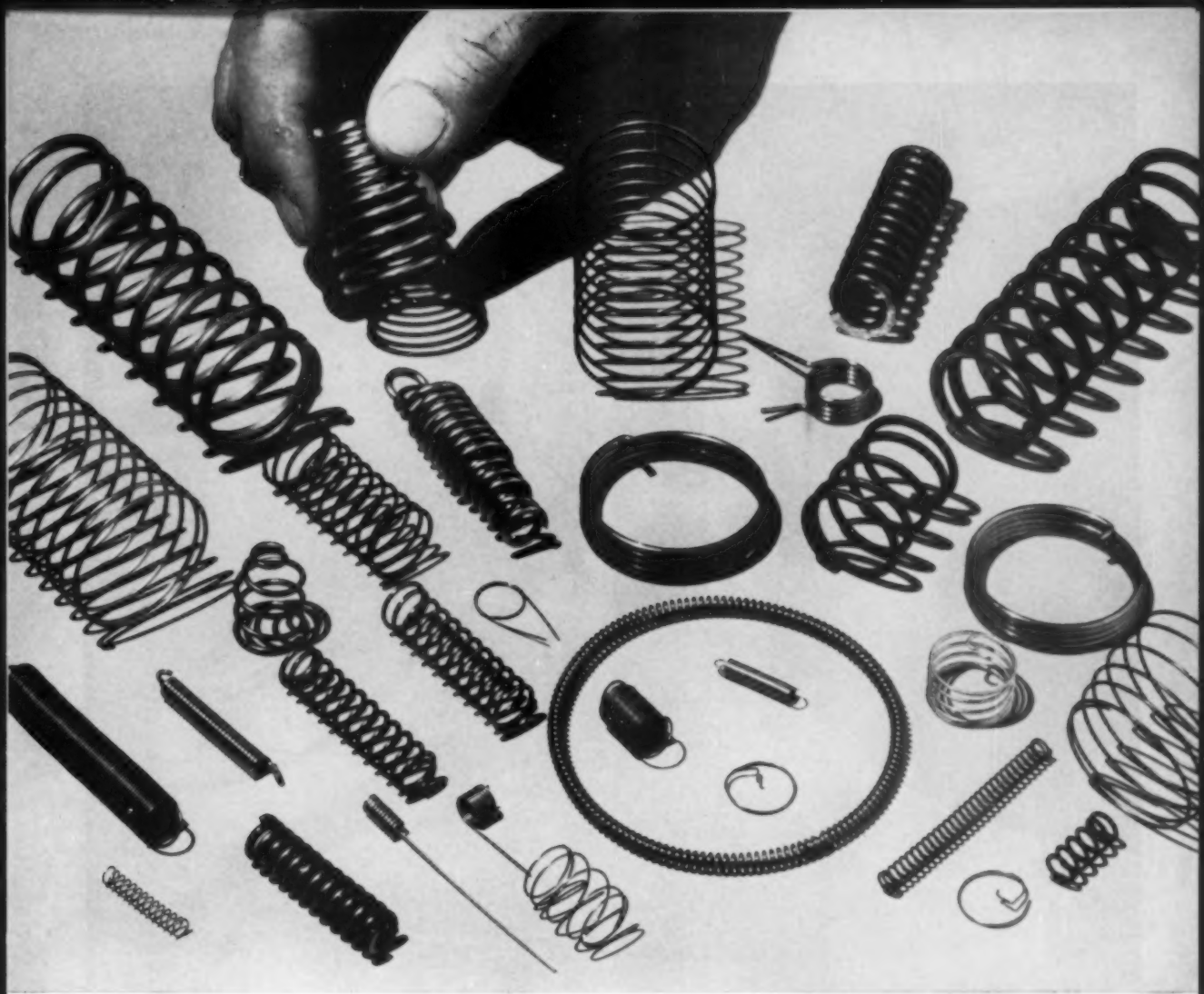
E. I. DU PONT DE NEMOURS & CO. (Inc.), POLYCHEMICALS DEPARTMENT
Room 119, Du Pont Building, Wilmington 98, Delaware.
In Canada: Du Pont Company of Canada (1956) Limited, P. O. Box 660, Montreal, Quebec.

Please send me more information on the Du Pont engineering materials checked: ☐ ZYTEL; ☐ ALATHON; ☐ TEFLON; ☐ LUCITE. *I am interested in evaluating these materials for:*

NAME _____ POSITION _____
COMPANY _____
STREET _____
CITY _____ STATE _____
TYPE OF BUSINESS _____

NEED MORE INFORMATION?

For further details that will help you evaluate these Du Pont engineering materials for use in your product development programs, mail the coupon at left.



How the right "COAT" solves many spring problems

● Unless you yourself go in for forming wire springs, you have no idea what a tricky business it is. For one thing, as every fabricator knows, it takes extreme uniformity in the wire to obtain the precise dimensions and the exacting tension, torsion or compression characteristics so often required.

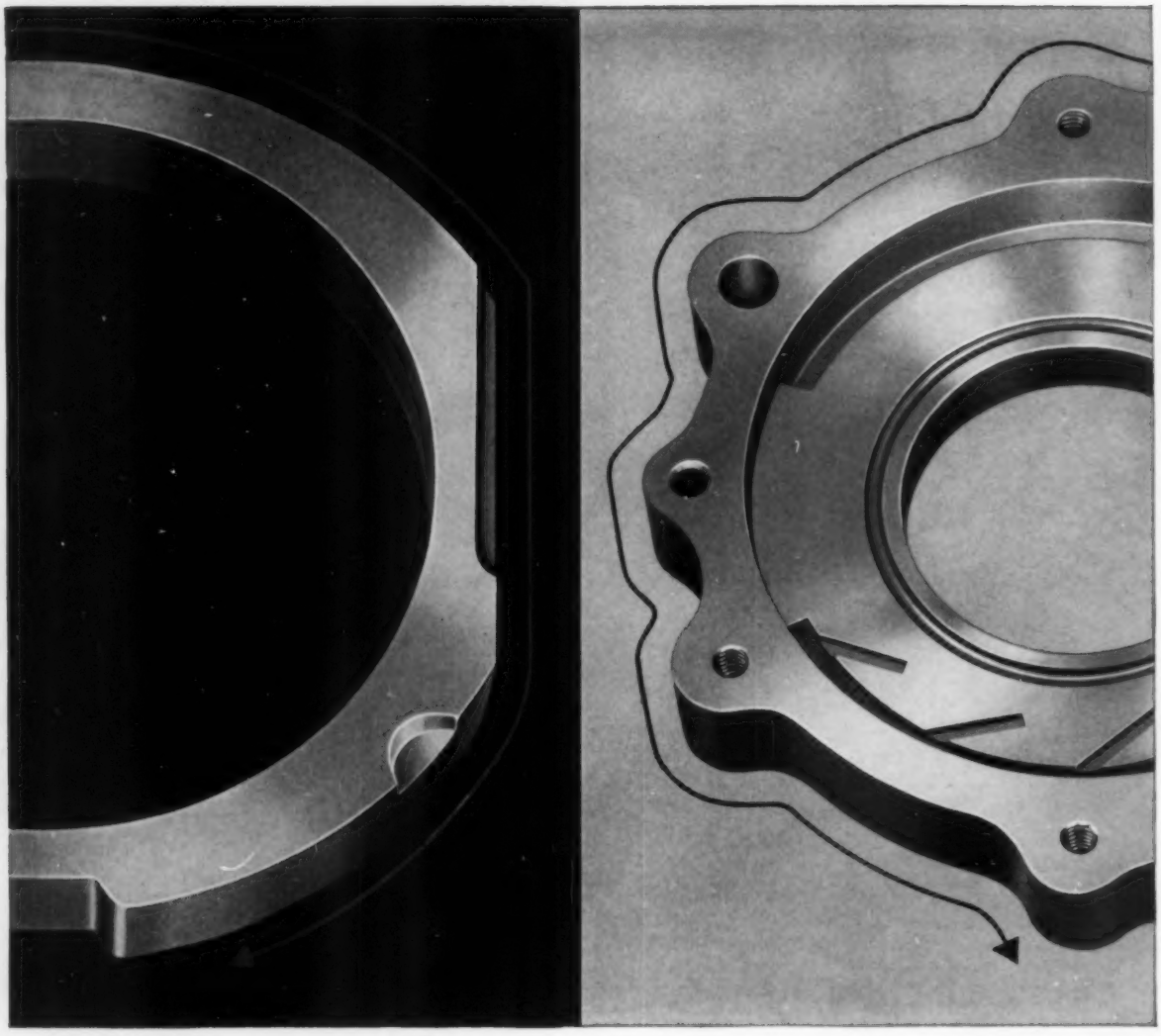
But uniformity alone won't always do the trick! As a leading supplier of special wire for tougher-than-usual spring requirements, National-Standard has delved deep into production problems and has come up with answers that help many a fabricator hold better to tough specifications and produce faster with less waste and more profit!

Time and again, for example, National-Standard has shown that merely a change in wire *coating* or lubrication quality is of major importance in forming operations. Proper coating also helps gain uniform dimensional response to heat treating. Quite often, in fact, troubles chalked up to wire variance are really the fault of improper coating or finish.

Helping fabricators solve problems and cut costs is a National-Standard specialty. We're geared for it and make a point of it. Try us and see!

NATIONAL NS NATIONAL STANDARD **STANDARD**

DIVISIONS: NATIONAL-STANDARD, Niles, Mich.; *tire wire, stainless, music spring and plated wires* • WORCESTER WIRE WORKS, Worcester, Mass.; *high and low carbon specialty wires*
WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • ATHENIA STEEL, Clifton, N. J.; *flat, high carbon spring steels* • REYNOLDS WIRE, Dixon, Ill.; *industrial wire cloth*



Does *complexity* limit use of metal powder?

One shape is simple, the other complex. And while these parts have widely different applications and performance characteristics, *both* were easily produced from metal powder.

Costs were cut because each part could be mass-produced in a single press operation. Yet, closer-than-ever tolerances were maintained.

Moraine Products has the experience gained from the production of hundreds of millions of metal powder parts in an infinite variety of shapes and sizes. This experience and our familiarity with other types of production processes guide our engineers in determining whether our materials and our processes are best suited to the production of a specific part.

When we accept a job to make metal powder parts, it is only after thorough study has shown that the customer will receive parts of the highest uniform quality for dependable end-product performance. Of course, on-time delivery is assured regardless of quantity.

Moraine Products also produces: Moraine Power Brakes—Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders, and parts—Moraine friction materials—Moraine-400 and M-100 automotive engine bearings—self-lubricating bearings and porous metal filters—rolled bronze and bi-metal bushings.

Another General Motors Value

Moraine Products
Division of General Motors, Dayton, Ohio

Perspectives

IN DESIGN AND DEVELOPMENT

WHY RESEARCH?

What determines a company's expenditures for research and development? What factors limit research and development spending? How is the return on research and development appraised? These and other questions along this line were included in a survey of industrial research and development conducted by the Bureau of Labor Statistics for the National Science Foundation. The survey included a series of interviews with officials of about 200 corporations, and the information was sought primarily for the use of the National Science Foundation in developing policy recommendations to strengthen the scientific research effort of the country.

The 200 companies picked for interviews were chosen from the largest firms in industries with significant research and development programs. Together the companies accounted for more than two-thirds of the cost of research and development performed by private industry and employed more than half of the number of research and development scientists and engineers on company payrolls.

The companies were spread out over the following industries: 33 in chemicals and allied products; 21 in machinery; 20 in electrical equipment; 14 in petroleum; 13 in professional and scientific instruments; 11 in food products; 9 in aircraft and parts; 9 in fabricated metal products; 9 in primary metals; 8 in motor vehicles and equipment; 7 in mining; 7 in rubber products; and smaller numbers in many other fields.

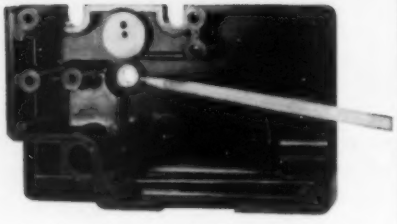
THESE ARE THE ANSWERS

Competition faced by the companies is the main reason for their research and development programs. However, a large proportion of the companies look beyond this immediate stage and gear their research programs and budgets to longer range plans that will continue the company's stability and growth. More than three-fourths of the companies interviewed were conducting some longer term projects directed toward new product development and in many cases toward diversification. More than two-thirds of the companies were conducting some basic research.

Research and Development Budgets. More than half of the companies interviewed said that their research expenditures are determined by appraisals of company needs and resources. One of the standards used most frequently is the ratio of research costs to sales. But these companies using such standards said that they did not rely too heavily on them, and no company applied such standards routinely to get an exact figure for research costs. One chemical company reported that its over-all budget increases by 6 to 8 per cent per year, and that the research and development budget keeps pace with this. The annual growth of research and development should be restricted to 8 per cent, according to this company. An electrical equipment company expanding its research program estimated that an expenditure of 3 per cent of its net sales would not be out of line.

Government Financed. Research and development activities in private

(Continued on page 131)



A unique phenolic part with a nylon bearing insert helps the Servel "Ice-Maker" make ice in a new way and in a new shape.

NOW! ICE CUBES MADE *automatically!*

Combined molding of thermoplastic and thermoset materials helps assure trouble-free operation

If your next refrigerator is a Servel Icemagic, you'll find it solves the problems of ice-tray handling. It *eliminates* the tray—makes tumbler-round ice "cubes" automatically.

Part of the story behind this revolutionary development is a unique plastic part. It's made of phenolic—mostly, that is. However a small nylon bearing has been molded into the phenolic part. As a result, this self-lubricating nylon bearing allows the ice ejector arm to rotate freely . . . eliminates oil and any chance of ice contamination.

This was quite a trick . . . combining nylon and a phenolic. One's a thermoplastic; the other's a thermosetting plastic that requires molding heat that will normally soften a thermoplastic. To make a molding from both materials was like putting oil and water together. However, by selecting special formulations, and molding under mechanically contrived temperatures and conditions, Chicago Molded *did* the trick.

Whatever your new product needs, you'll find it pays to call in Chicago Molded. CMPC engineers *know* plastics, and they know how to help you make your product more saleable, yet less costly.

If you are interested in new plastic developments, let us send you a complimentary subscription to Plastics Progress. No obligation, of course.

CHICAGO MOLDED PRODUCTS CORPORATION

1032 North Kolmar Avenue, Chicago 51, Illinois

industry depend a great deal on the amount of government financed research and development, particularly in the aircraft, electrical equipment, telecommunications, and scientific instruments industries. Officials in these companies said that any substantial reductions in government contracts would reduce the research and development activities temporarily. Conversely, it was reported that even if there were substantial increases in the government research and development contracts, it would not lead to an equal expansion in industrial research and development because of shortages of well qualified personnel.

Basic Research. Most basic research in industry is a result of problems encountered in applied research programs, or the recognition of potential of certain basic information in a field of company interest. As a rule companies do not budget their basic and applied research programs separately. But a few companies specifically allocate funds for basic research so that they can be sure of a continuing program. This amount is usually at a constant proportion of the over-all research budget.

WHAT IS THE RESEARCH WORTH?

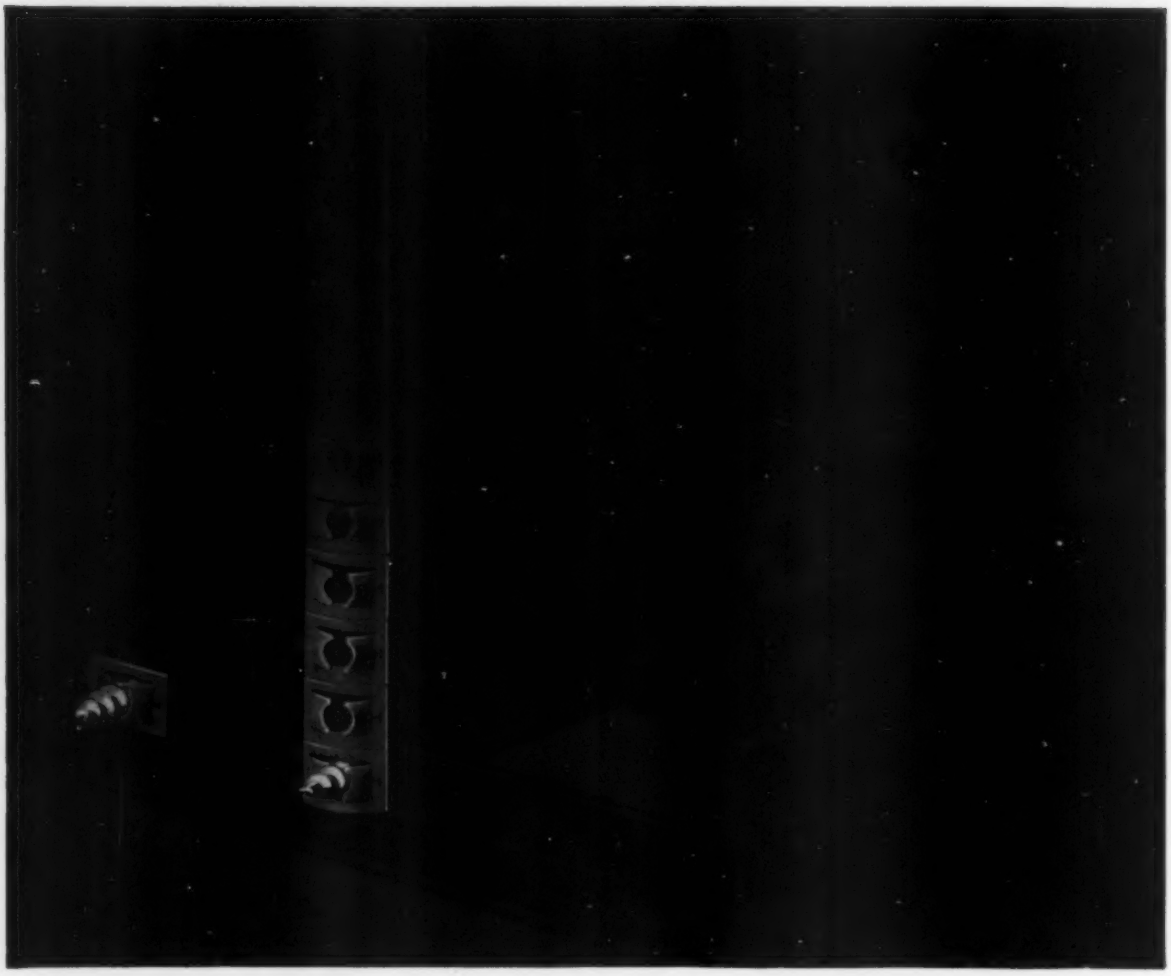
All of the company officials questioned expressed great interest in the methods of measuring the return on research, the reason being that it would improve subsequent research planning and budgeting. Nevertheless, only one-fourth of the companies interviewed said that they had developed formal methods for evaluating research. Most of the companies have not found a satisfactory solution to this problem, and depend to a large extent on their own judgement in appraising the contribution of research. These appraisals are based on such information as the proportion of total company business, the percentage of total products on the market, or the number of patents granted which are the result of the company's research. Some estimates of research success are based on the acceptance of the new products, or the general progress of the company. An electronic equipment company which watches the sales of new products reported that 60 per cent of the company's business was the result of products which did not exist 10 years ago. A chemical company said that two new products marketed in the past few years accounted for about half of the company's sales. Few companies estimated the financial return on all types of projects in their applied research programs.

WHAT LIMITS RESEARCH AND DEVELOPMENT?

The manpower situation was the first reason given on this score. The shortage of well-trained and qualified scientists and engineers for research and development work was stressed more than the shortage in numbers.

The second reason was that companies need more basic research before they can continue on with their work. Companies in a wide range of industries reported a shortage of sufficient basic data for their current programs, and other companies expect a shortage in the near future.

Only a few companies reported that they lacked the capital to finance research and exploit the results. Most companies reported that they had the money for the projects considered worthwhile. Using capital for additional research, however, and for turning the results of this research into production depend strictly on the business outlook.



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eliminate fastener fumbling!

Multiple-unit strips of Tinnerman Flat-Type SPEED NUTS permit cost-cutting, split-second fastening. That's how Reznor Mfg. Co., Mercer, Pa., saves up to 40% in the assembly of louvers for its Suspended Gas Unit Heaters!

With strip in hand, the operator drives a screw into the end SPEED NUT, easily snaps off the tightened fastener from the strip and quickly places the next SPEED NUT in screw-receiving position. No lost motion feeling or fumbling for single fasteners, spanner or lock washers. Louvers are securely fastened, and are easily adjusted to control air distribution.

This is an example of the versatility of SPEED NUTS. It is also an example of the assembly advantages of SPEED NUT brand fasteners. Over 8000 types give you an answer to almost every fastening problem. See your Tinnerman representative or write for complete details.

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FASTEST THING IN FASTENINGS®

Expands: Dominion Fasteners, Limited, Hamilton, Ontario, Great Britain: Simmonds Aerocessories, Limited, Treforest, Wales. France: Simmonds, S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). Germany: Bues Stanzwerk GmbH "BECANO", Lengo (-kupp.

Raiding isn't Recruiting

Recruiting of engineers is too frequently just plain raiding. It's a refined form of the cave man's wooing with a club, the modern club being money, title, or help in getting a house.

The West raids the East; the new company raids the old. Trade shows and conventions are open seasons, because the concentration of "up and coming" men is higher. One whole floor of New York's recent Automation Show was given over to "recruiting booths", complete with cocktail invitations and models (*not* of company products) as bait.

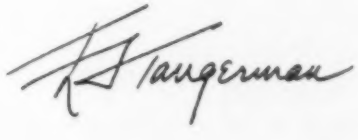
Everybody seems to need engineers. But some of the current shortage is as synthetic as some materials shortages have been. The seed is failure to use engineers as engineers, draftsmen as draftsmen, clerks as clerks. It is nurtured by the trick of "stockpiling" engineers—hiring more than necessary "just in case", or for eventual thinning out. It flowers because engineering incomes haven't kept up with hourly wages and the cost of living, so aggressive engineers desert the profession for more lucrative work.

It is disgusting to see engineers doing simple calculations, detail design, or clerical work that less-skilled people can do at less cost. The excuse is that such help isn't authorized, or that the budget doesn't allow it. Often, the real truth is that management hasn't learned to use engineers at top efficiency. Traditional ways of handling engineers are still in use. The new and the experienced engineers are assigned the same kind of work indiscriminately, and starting salaries approach eventual top ones. So the engineers lose heart, lose faith in what they're doing, and are ready and willing to be raided.

And raiding doesn't help anybody. It often does not justify its cost in time, effort, or money. Raiding subtracts top-quality men from constructive work at home. It distorts salary levels within the raiding company, creating discontent among longer-term employees. It leads the raided man to expect special treatment, to suspect that other recruits got even better deals, to assume the road upward is studded with job changes. Both raiding and raided companies pay through the nose to re-train nomads.

The time has come for a realistic, practical and civilized evaluation of the problem. What about first "building from within"—properly classifying and sorting out the jobs that can be done by less-skilled people, finding the engineering-minded worker who can be upgraded to technician, giving or assisting in training courses that produce needed specialists, recognizing and encouraging achievement by adequate salary advances?

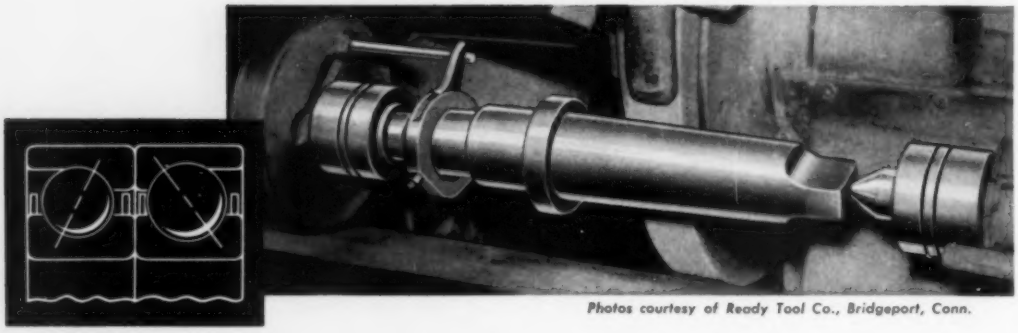
The best recruiting is done at home—by building an efficient, skilled and integrated working force.



FACTS

about

NEW DEPARTURE BALL BEARINGS



Photos courtesy of Ready Tool Co., Bridgeport, Conn.

PRELOADED BALL BEARINGS HELP CENTER MAKERS GUARANTEE ACCURACY TO WITHIN .000050"!

Accuracy . . . *to within less than .000050" total indicator run-out!* That's the performance live centers designed around New Departure preloaded ball bearings deliver!

Such super accuracy of work stems from *extreme rigidity* . . . the unsurpassed ability of these preloaded duplex ball bearings to handle combination loads with minimum deflection.

In live center applications, New Departure ball bearings with medium and high contact angles are mounted duplex and positively clamped together to assure the correct predetermined preload condition. As work expansion increases the thrust load, radial centering becomes more rigid and accuracy is precisely maintained.

New Departure ball bearings for live center applications are made to ultra-precision tolerances. Smooth operation with low frictional loss is assured, as well as continuity of accuracy throughout long life. Write for further details.

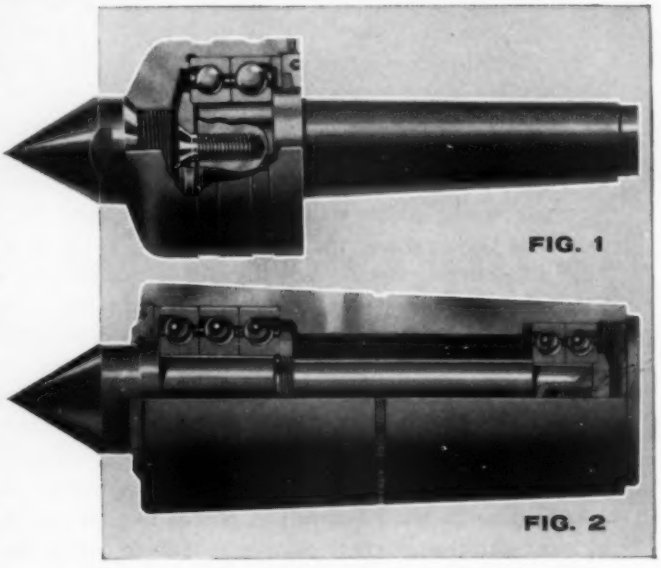


FIG. 1

FIG. 2

(Fig. 1) Shank type center in which New Departure ABEC 7 specification duplex ball bearings support grinding loads with undiminished accuracy throughout long use.

(Fig. 2) Enclosed spindle center designed around five New Departure ultra-precision preloaded duplex ball bearings.

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BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

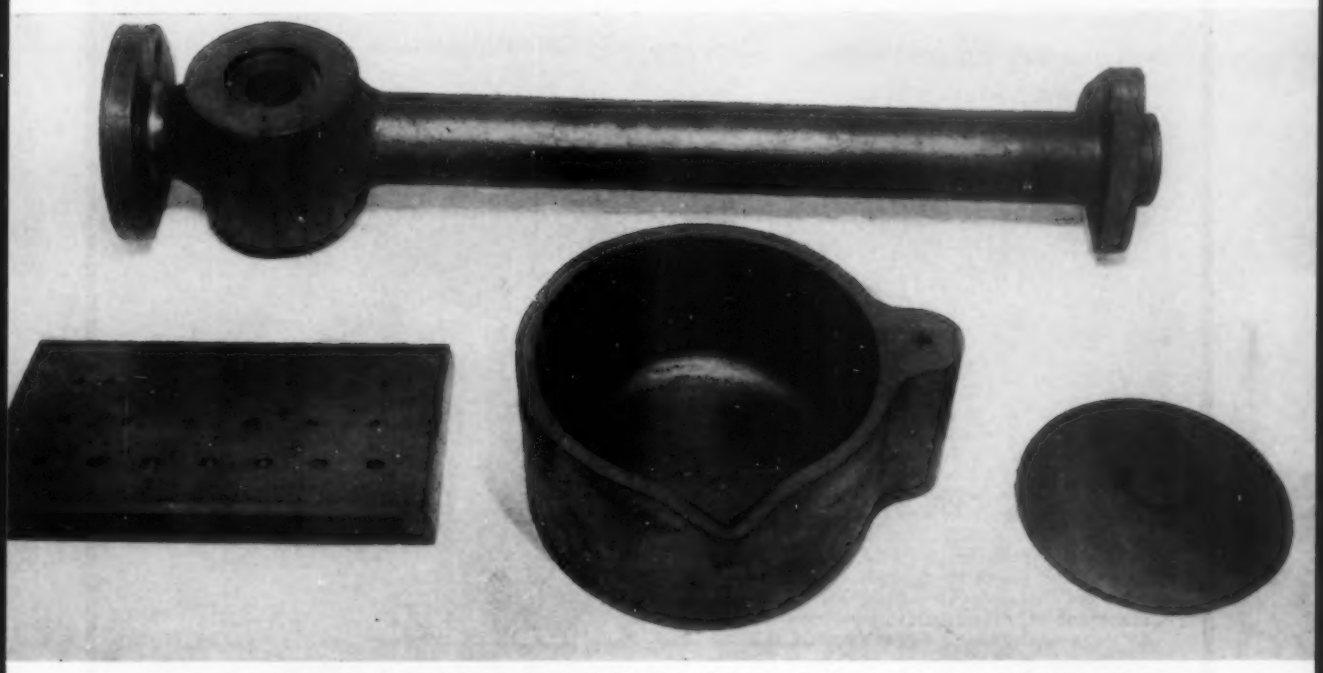


Fig. 1—Parts made of silicon carbide bonded with silicon nitride. Top: discharge tube for centrifugal pump handling molten metal (see box on following page); bottom, left to right: orifice manifold for air supply in domestic coal furnace (note cored orifices of varying sizes in upper surface), ladle for molten aluminum, and a crucible cover.

Nitride-Bonded SILICON CARBIDE . . .

Bridges gap between metals and ceramics

W. L. Wroten, Senior Engineer
Refractories Division, Carborundum Co.

Man-made material bonded with silicon nitride yields kiln-fired parts with remarkable resistance to heat, abrasion and corrosion. Shapes and sizes possible, profile limitations, surface finish; mechanical properties at elevated temperature; application and cost data.

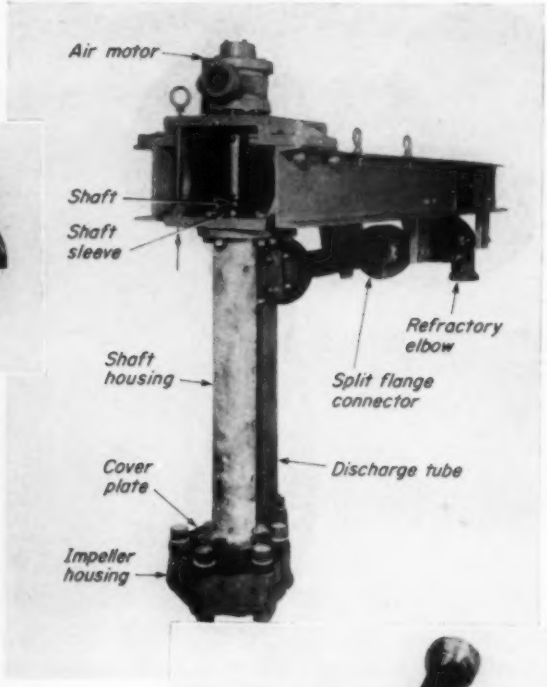
HIGH TEMPERATURE MATERIALS technology has emphasized the gap between metals and ceramics. Metals have greater strength, easier workability and wider variety through alloying. They lack, however, some properties peculiar to ceramics such as good hot strength, corrosion and abrasion resistance.

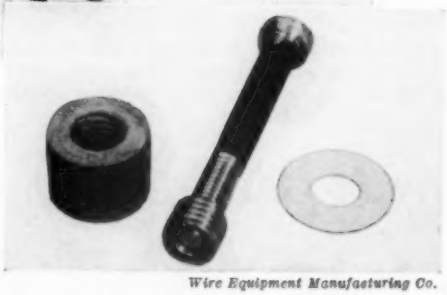
Special purpose alloys attempt to narrow this gap from the metals side: high temperature alloys, stainless steels and abrasion resistant alloys. Silicon nitride-bonded silicon carbide has been developed in an attempt to bridge the gap ceramically. Bonded with silicon nitride, the new ceramic has improved hot strength over clay-bonded silicon carbide, while retaining its refractory character and resistance to corrosion and abrasion. Four parts of varying intricacy formed of this material are shown in Fig. 1.

Silicon carbide is a man-made mineral, produced in an electric furnace at 4000 F from a charge of sand and coke. For refractory purposes it is an extremely hard black hexagonal crystal (see cover) that does not soften, melt or dissociate below its temperature of formation.

Refractories of silicon carbide in the past have been made by mixing these crystals with ceramic or siliceous bonds, forming to the desired shape and firing to fuse the bond which holds the silicon carbide crystals together. These bonds are much less refractory than silicon carbide, begin to soften at temperatures below their melting point, and lack resistance to thermal shock and chemical attack.

Refractory Pump Transfers Molten Aluminum





Wire Equipment Manufacturing Co.

Nitride-bonded silicon carbide replaces cast iron in centrifugal pump transferring 100 tons per hr of molten aluminum at 1500 F. Cast iron corrodes after short service in aluminum. Stainless steel is also unsuitable: top insert shows aluminum attack on stainless pump impeller after 30 min. operation. Pump shows that intricate, close-tolerance parts can be made with nitride-bonded silicon carbide. All parts are cast and used without finish machining. Key to successful refractory design is to avoid abrupt changes in cross section.

Stainless drive shaft is protected from aluminum corrosion by silicon carbide sleeve pinned to shaft. Composite shaft is guided in shaft housing by upper and lower silicon carbide bushings. Lower bushing is lubricated by aluminum; upper bushing runs dry. Four holes in housing minimize thermal shock upon immersion by admitting metal to pump interior; drainage is also facilitated during pump removal.

Shrouded impellor threaded on shaft sleeve is made of two parts fired together after assembly: upper part comprises hub, 4 in. diameter upper shroud and 4 curved blades ⅜ in. thick; lower part is bottom shroud plate routed to fit bottom edge of blades for greater strength. Refractory mixture is wiped into joint to form a fillet, and the assembly re-fired providing integral impeller.

Pump housing is cast with interior volute, cored bosses at six points to pass stainless studs, and 2 in. suction opening at center of impeller. Cover plate is separate part re-fired to shaft housing. Stainless bolts are protected from corrosion by silicon carbide caps threaded tightly over ceramic wool gaskets (bottom insert). Gasket material is 50-50 alumina-silica and can be die cut easily.

Molten aluminum enters pump suction at "eye" of impeller, is swirled outward around volute to discharge chamber and upward through tube bolted to cover. Discharge tube is cross-cored to provide 90 deg bend is shown in Fig. 1. Two-foot sections of silicon carbide tubing are connected to pump and each other with recess-shoulder construction, using split-flange compression connectors with ceramic wool gaskets. Note slotted connector supports for differential thermal expansion between channel frame and ceramic pipe. Pump is driven at 1500 hp by 3 hp air motor.

They also undergo a volume change during drying and firing that prevents close dimensional tolerances.

In the new technique, silicon metal replaces clay in the pre-fired mixture. During firing, silicon metal is nitrided, developing a stronger bond which increases strength of the refractory body. In addition, the nitride bond is more refractory than clay and does not soften but dissociates at 3450 F. It resists corrosion and has good thermal shock properties. Volume does not change during firing, thus permitting close dimensional control of finished parts. Room temperature properties of ordinary ceramic-bonded and nitride-bonded silicon carbide are compared in Table I.

Abrasion resistance of the final refractory, termed Refrax, is excellent since it consists of 85 per cent silicon carbide, exceeded in hardness only by boron carbide and diamonds. Wear plates and impellers for pumps handling abrasive slurries and nozzles spraying high velocity liquids or gases are instances where the material has been used successfully to withstand abrasion. Fig. 2 shows sprayers for jetting high pressure water and steam into catalytic gasoline cracking units.

Volume stability is an important factor in producing close tolerance parts such as valve bodies, fittings and pump components. This permits manufacture without the necessity of machining, which is difficult because of high hardness. The material itself has an extremely low volume

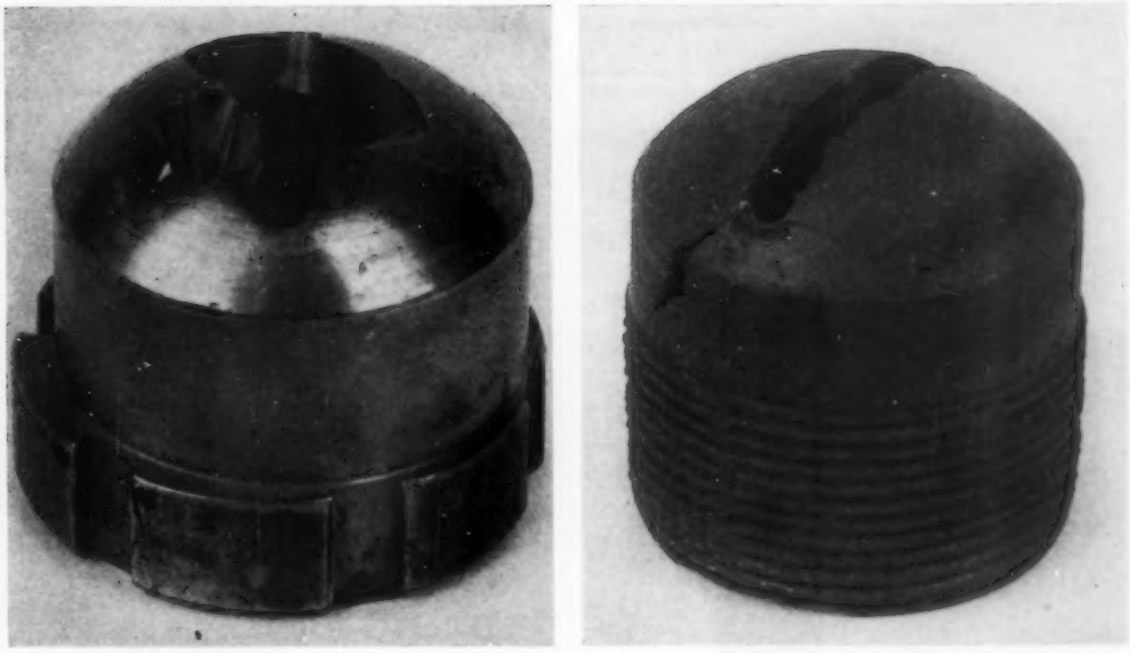


Fig. 2—High pressure water-steam refinery nozzles. Stainless nozzle (left) removed after 4 months operation. Nozzle redesigned to silicon nitride-bonded silicon carbide (right) shows slight wear after 7½ months. Note substitution of external for internal threads to avoid tensile thermal stresses when coupled to metal pipe. Crack made during removal.

change during drying and firing, permitting tolerances of ±.003 in. to ±.005 in. per inch of dimension.

Surface finish of nitride-bonded silicon carbide refractories varies with the method of manufacture. Parts may be made by compacting, pressing or casting. Method used depends on the shape, quantity, application and surface finish required. Cast pieces have a considerably smoother finish than pieces made by the other methods since fines of silicon nitride migrate to the surface. Normally cast shapes have a surface finish of approximately 250 micro-inches, whereas compacted and pressed parts have a finish of 500 micro-inches. Surface finish of either type can be improved by grinding. If carefully done with a diamond wheel, a finish of 32 micro-inches can be obtained.

These finishes, although good for ceramic-type materials, do not approach machined or ground metal finishes. Finer grain size will improve surface finish slightly, but this may adversely affect physical properties. Fineness of finish is limited by the granular nature of the material. A silicon nitride coating fused onto the surface of the part will improve machinability; other coatings are generally not practical because of thermal coefficient mismatch between coating and ceramic which causes spalling during thermal change. Ultrasonic vibration machining can be used to cut holes, slots and grooves in nitride-bonded silicon carbide parts.

Corrosive media such as gases, acids, salts and molten metals which are extremely detrimental to most metals have limited effect on nitrided silicon carbide. For example, it is neither wet nor attacked by molten aluminum, a notoriously corrosive substance; hence its application in pumps, valves and fittings for handling this fluid (see box).

Design Factors

Shape and size are extremely important. Many configurations are possible, but not all are practical. Extremes in thickness should be avoided as well as sharp changes in section. Walls less than ¼ in. are difficult to produce and are fragile. Sections over 2½-3 in. are equally undesirable since resistance to thermal shock is impaired. In general, parts larger than 30 in. and less than ¾ in. long are not considered practical. Very small parts cause manufacturing difficulties that may eliminate the cost advantage over metal. Long thin shapes tend to warp when fired. Examples of poor profile design are shown at (A) in Fig. 3; good profile design is illustrated by parts at (B). A good rule is: uniform cross sections with a minimum of projections. Where abrupt cross section changes cannot be avoided, the part can be made in separate pieces, the joint filled with casting mix and the assembly re-fired to form an integral unit.

Compression loading should be applied where possible, since nitride-bonded silicon carbide is considerably stronger in compression than in tension as shown in Table I. For example, in threaded joints with metal parts where temperature changes are large, the refractory is usually made the male part. Fig. 4 shows the redesign of a valve seat to replace shear stress by compressive stress.

Elevated temperature has limited effect on material properties over a wide temperature range as shown by Table II. A high coefficient of thermal conductivity distributes thermal energy rapidly within the part. Consequently, nitride-bonded silicon carbide is adapted to either slow or rapid temperature cycling. Top temperature for continuous usage is about 3000 Fahrenheit.

TABLE I — Properties of Silicon Carbide Refractories

Property	Ceramically-bonded silicon carbide	Silicon nitride-bonded silicon carbide
Tensile strength, psi (20 C)	very low	3,000
Compressive strength, psi (20 C)	15,000	20,000
Elastic modulus, psi (25 C)	13.2×10^6	17×10^6
Rupture modulus, psi (25 C)	about 2200	5500
Specific gravity	2.57	2.87
Porosity, per cent	9 - 17	6 - 10
Mean specific heat, Btu/hr/lb/F (0-2500 F)	0.2875	0.288
Mean thermal expansion, per deg C (0-2500 F)	4.4×10^{-6}	4.4×10^{-6}
Thermal conductivity, Btu/hr/sq.ft/F per in (at 2200 F)	109	113.5

TABLE II — Elevated Temperature Properties of Nitride-Bonded Silicon Carbide

Property	Temperature, C	Value
Rupture modulus, psi	25	5500
	700	5500
	1000	7000
	1350	5900
	1500	3000
Tensile strength, psi	25	3500
	700	3500
	1000	4500
	1350	3700
	1500	1900
Compressive strength, psi	25	20000
	700	20000
	1000	25500
	1350	21500
	1500	11900
Elastic modulus $x10^6$, psi	25	17.0
	700	16.0
	1000	9.5
Specific heat, Btu/hr/lb/F	0	0.197
	1000	0.297
	1400	0.372
Thermal expansion coefficient $x10^{-6}$, per deg C 25 C to:	200	3.26
	400	3.76
	600	4.07
	800	4.29
	1000	4.47
	1250	4.69

Abrasive and corrosive environments are good fields of application for nitride-bonded silicon carbide. Refrax itself is abrasive, however, so that rubbing contact with metals should be avoided.

Electrical characteristics of this material are unknown, however, it is considered a semi-conductor and its d-c resistivity decreases with temperature. Consequently, when it is to be wound with resistance heating elements, some electrical insulation must be placed between the winding and the refractory part to prevent short circuits.

Cost of silicon nitride-bonded silicon carbide parts varies with complexity and size from $0.50 per pound for very simple shapes to $5.00 per pound for the complex. Such parts are generally more expensive than cast iron or mild steel, but less than alloy parts. Compared to machined alloy parts, considerable savings are possible.

Applications

Correct and incorrect application of silicon nitride-bonded silicon carbide are shown by the following examples:

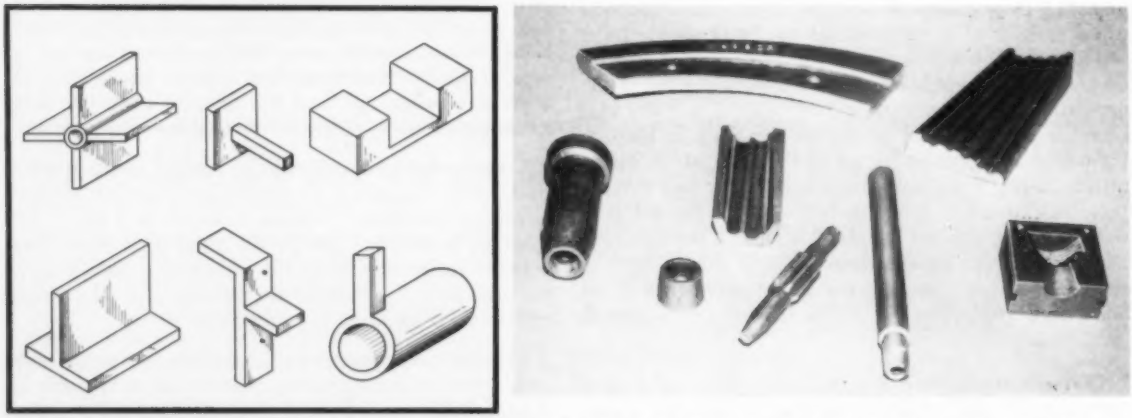


Fig. 3—Examples of poor refractory section design are sketched at left. General rule is: uniform cross sections with a minimum of projections. Good design practice is illustrated in photo; left to right: spray nozzle, abrasion resistant facing for screw-type conveyor (apparent warpage is pre-cast screw pitch), bushing, one half of brazing fixture, core of two-piece ceramic kiln burner operating at 3200 F (note flutes for mixing fuel and air), thermocouple well for molten aluminum bath; second brazing fixture, and mold for casting brass fitting (note as-cast threads).

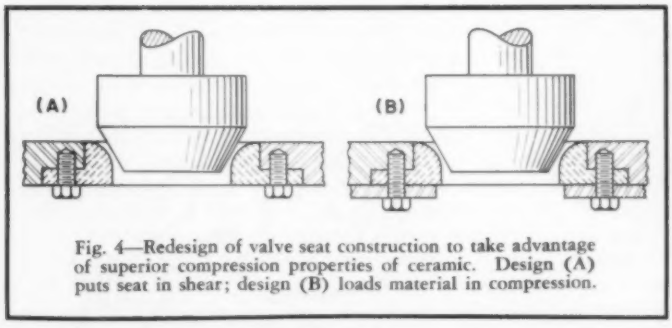


Fig. 4—Redesign of valve seat construction to take advantage of superior compression properties of ceramic. Design (A) puts seat in shear; design (B) loads material in compression.

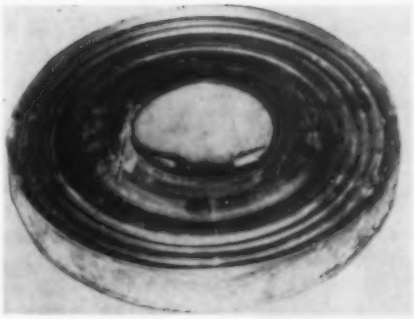


Fig. 5—Acid spray nozzles of nitride-bonded silicon carbide. At left, as-cast nozzle (note internal threads); at right, nozzle after 4 month's service with hydrofluosilicic acid shows no wear.

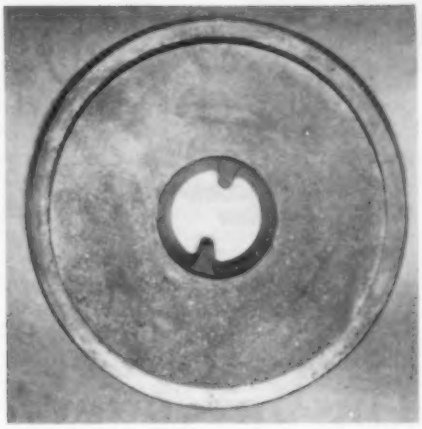


Fig. 6—Centrifugal pump suction cover of high nickel-molybdenum alloy used in abrasive acid slurry eroded severely (top) and was removed after 5 months. Replacement cover of silicon nitride-bonded silicon carbide is shown at bottom with no visible wear after 10 months.

1. Acid spray nozzle shown in Fig. 5 was originally machined and threaded bronze alloy casting. Nozzle sprayed hydrofluosilicic acid at low temperature and moderate pressure. Acid corroded the alloy and erosion by suspended abrasive particles enlarged nozzle opening in a few weeks. From a refractory design standpoint, the shape was of moderate size with a fairly uniform wall, stressed only by internal fluid pressure. Redesigned with nitride-bonded silicon carbide, the nozzle required no machining or threading. Nozzle functioned 4 months with no measurable change in orifice diameter, as shown in Fig. 5. Cost of bronze and refractory nozzle were about the same.

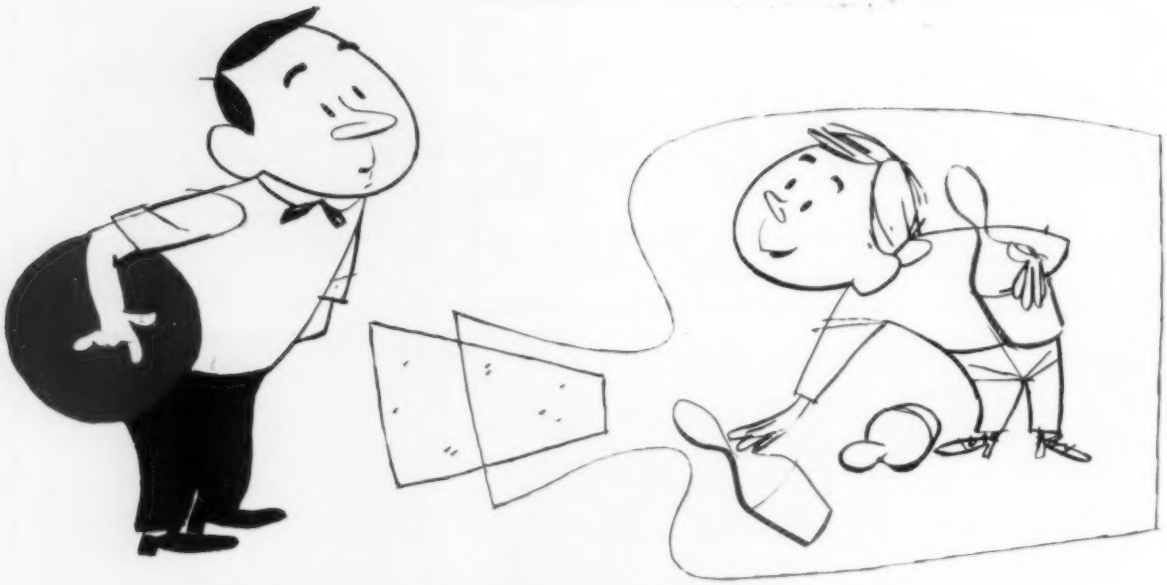
2. Centrifugal pump suction covers in Fig. 6 belong to a pump handling an abrasive acid slurry. The high nickel-molybdenum alloy cover at (A) had a service life of 5 months. Alloy cover proved expensive, difficult to machine and subject to erosion, causing frequent shutdowns. As a refractory, the part is somewhat massive; however, thermal shock was not present which frequently causes cracking in parts with heavy sections. The cover was loaded only in compression. Redesigned to nitride-bonded silicon carbide, the part at (B) shows negligible wear after 10 months and now has over one year's service; in addition, the cost was halved.

3. Cast iron spout for continuously casting molten aluminum corroded and dissolved in the bath, contaminating the castings. Geometrically, the spout was a 9 in. truncated cone, 2 in. diameter at the small end flaring to 4 in. diameter. Attached to the pouring trough with four ¾ in. bolts in a 6 in. diameter flange, the spout conveyed metal at 1500 F to the molds.

Since the shape was simple, moderate in size with uniform wall thickness, it was duplicated in nitride-bonded silicon carbide. Although the corrosion and contamination problem was solved, differential thermal expansion between trough and spout caused cracking in the flange initiating at the bolt holes. Thermal cycling from pour to pour widened these cracks causing eventual failure of the flange. The spout was redesigned for a material with closer coefficient match to the trough. Thus, care must be exercised to avoid excessive tensile stresses.

4. Brazing fixtures of nitride-bonded silicon carbide are shown in Fig. 3(B). Compared with alloy fixtures, these have lower first cost, longer life and do not require periodic reworking. Also, the material resists wetting by the brazing alloy.

Raw materials for producing bonded silicon carbide are in abundant supply. Proper design techniques and methods of fabrication for this material have been established. Obviously, silicon nitride-bonded silicon carbide has certain limitations which often eliminate it from consideration. Often, however, these are not important factors; in others careful design can minimize their effect.



"Pin boys are no longer the bottleneck, because . . ."

This Invention Revolutionized an Industry

Conception and invention of the automatic bowling pin setter, and the patenting process which protected it through years of development.

GEORGE S. HASTINGS

Vice President in Charge of Patents
American Machine & Foundry Co.

ONE DAY IN 1936 when Fred Schmidt, a young engineer, went to the bowling alleys at Pearl River, N. Y., for his regular league game, the pin boys didn't show up, disrupting the league schedule. George Becherle, operator of the alleys, told Schmidt of all the troubles he and 16,000 other certified alleys had with pin boys.

He asked the young engineer why he didn't invent an automatic pinsetting machine. Said Fred, "That's easy." He couldn't have been more wrong.

An idea had occurred to Schmidt which he thought might be the basis of a successful pin-handling device. He reasoned that the top of a bowling pin was generally the least battered part. He thought of using an inverted suction cup to pick up the pin by this top portion. Also, as the pin entered the cup, it would push up a plunger activating a suction valve in the cup. The pin itself would cause the mechanism to determine whether suction in the cup should turn on. In short, the machine could be made to act according to the presence or absence of standing pins on the alley.

Fred Schmidt was anxious to build a machine embodying his ideas, and Becherle agreed to help finance it. With a draftsman from the plant where Schmidt worked, they went to work. Having little money, they had to make do with what was handy. They obtained the use of a 15x15-ft turkey house at Pearl River and fitted it out with drawing board, bench, what tools they had between them, and a coal stove.

Part of the machine was made from scrap from Fred's company. Metal lamp shades were used to make the respotting mechanism. For a vacuum pump, a hose was attached to the intake manifold on a car belonging to one of them.

In time, the critical parts of the machine functioned sufficiently well so that they felt they were ready to file a patent application.

The attorney who had patented some of Schmidt's other inventions made a preliminary search. They were taken aback by the number of patented attempts at making a pinsetting machine which turned up. The attorney pointed out the differences which in his opinion were patentable and several patent applications were filed.

In the summer of 1937, Morehead Patterson, now president of American Machine & Foundry Co., learned of this machine. Patterson was looking for something new to keep a Brooklyn plant busy. The large number of bowling alleys and their crying need for an automatic pin-setter appealed to him. The idea of mechanizing a growing sport seemed in keeping with the rapid growth of leisure-time activities in this country.

So Patterson visited the turkey house and watched the junkyard production actually set, though somewhat halt-

ingly, full-size tenpins on a stub alley. After the first ball was thrown, the machine lifted the standing pins, swept the fallen pins into the pit and even returned offispot pins to the same offspot positions, as called for by the rules of the game. Also, the machine responded to a strike by going into a strike cycle and replacing all the pins, with some emergency manual help from Schmidt.

After negotiations, an option on an exclusive license under the protection of Schmidt's patent applications was arranged. Next, the commercial practicability of the machine had to be investigated: could it be made to work reliably? Could it be made at a price so that it could take the place of one poorly paid boy? Would service costs be reasonable? Would it be approved by the American Bowling Congress? Would it slow up the game, or wear the pins too rapidly?

Finally, could sufficient patent protection be obtained on this machine to justify putting into it hundreds of thousands of dollars, and ultimately, perhaps millions? And was Schmidt's patent free from infringement on the patents of others?

A collection was made of all automatic bowling pin-spotter patents. An infringement was revealed.

In the applications filed, no claims of any consequence had been allowed and the applications were approaching final rejection. However, during these studies new light had been shed on what was valuable in the machine. Claims defining the invention were revised and added to, the examiners interviewed in the light of new evidence of the value and novelty of the claims, and good claims were obtained to most of the characteristic features of Schmidt's machine. The infringement was solved by purchasing the infringed patent.

One of the company's best designer-engineers worked with Schmidt to make a commercial machine of the inventor's crude model. He took Schmidt's ideas and added some of his own, and early in 1938 he had put together a machine known as the "Model A".

The Model A did everything a pin boy was expected to do. It was installed on a full-size alley and many bowling-alley operators were invited to roll against it. They were highly enthusiastic. However, about that time the United States became involved in World War II and the option with Schmidt and his associates was dropped in favor of defense work.

As the war approached its end, a little figuring indicated that the automatic pin-setter was one of the licensee company's most promising potential products, if it could be made cheaper, lighter, more troublefree and faster. Pin boys were even scarcer and more expensive. Recreation facilities were booming.

So the company reentered negotiations with Fred Schmidt and his associates. By then, many fairly broad claims had been obtained in the Schmidt applications and no other way of building a machine which met all bowling-alley requirements was known.

This time, said Schmidt, no option agreement. It must be a final agreement. Negotiations were long and sometimes acrimonious. Finally a carefully drawn, exclusive license agreement was entered into, in which AMF agreed to pay a royalty on each machine made by it.

The Model A machine was brought out and given further testing and improvement. Next, two improved versions were built and exhibited at the annual ABC bowling tournament in Buffalo, in 1946. Thousands rolled against it. There was great enthusiasm for the machine. The officials of the ABC looked it over and found it good. Many alley owners bgean making excited inquiries as to when they could have one. Many sent in unsolicited orders.

But the company was not at all happy about the Model A. AMF was doing a lot of figuring. The machine cost too much to compete with pinboy fees. Service and parts costs were too high. Two alternative models were built at

". . . an inverted suction cup to pick up the pin"

considerable expense trying to solve these problems, but without much success. There was some soul searching as to whether a pin-setting machine was really economically possible.

Finally, a reorganized engineering group decided to throw much of the existing machine overboard, together with an investment of over $1 million, and start over again. It was decided to discard the heavy cams and cam followers, along with complicated mechanical interlocks and controls, in favor of simpler electrical controls and drives. It was also necessary to eliminate suction pumps and certain other features that added to complexity and expense.

All this resulted in the Model B machine, forerunner of the present automatic Pinspotter. This machine was given day and night testing and after various changes operated so satisfactorily that four similar machines were built and installed in a small bowling center where they were run under commercial conditions for over a year.

A full-scale field test was indicated, and twelve machines were built and installed at Mt. Clemens, near Detroit, in 1951. These machines gave a good account of themselves, and it was decided to go ahead with the present production machine.

What happened then would probably be a revelation to many inventors who feel that the principal job in commercializing a new machine is to make a satisfactory, full-size operating model.

Detailed production drawings were completed, tools were designed and built at a cost of several hundred thousand dollars. Purchase orders for various components were sent out. A school for service men was organized. Equally important, facilities were set up for training local millwrights and local contractors in each city where the pinsetting machines were to be installed. Since it was decided to rent rather than sell the machines, rental agreements were drawn up. A sales force was organized and sent into the field. Brochures, advertising literature and service manuals were prepared.

The first production lot of Pinspotters was completed and installed, putting the finished product actually on its way. By this time the company had several million dollars invested.

Approximately ten thousand automatic pin-setters have now been placed in operation. Many hundreds of jobs have been created. Schmidt and his associates have become quite well-to-do, and 15,000 AMF stockholders are happier because of the improved corporate income.

But the greatest effect was on the bowling alleys and on the bowlers. It eliminated dependence on unstable, substandard labor. It greatly reduced the intermittent and seasonal nature of the business. The machine transformed the industry into one attracting a higher class of operators, better financing, and resulted in the building of finer recreation centers. This in turn brought out a better class of bowlers and induced them to bring their families, changing the whole tone of the average bowling alley operation.

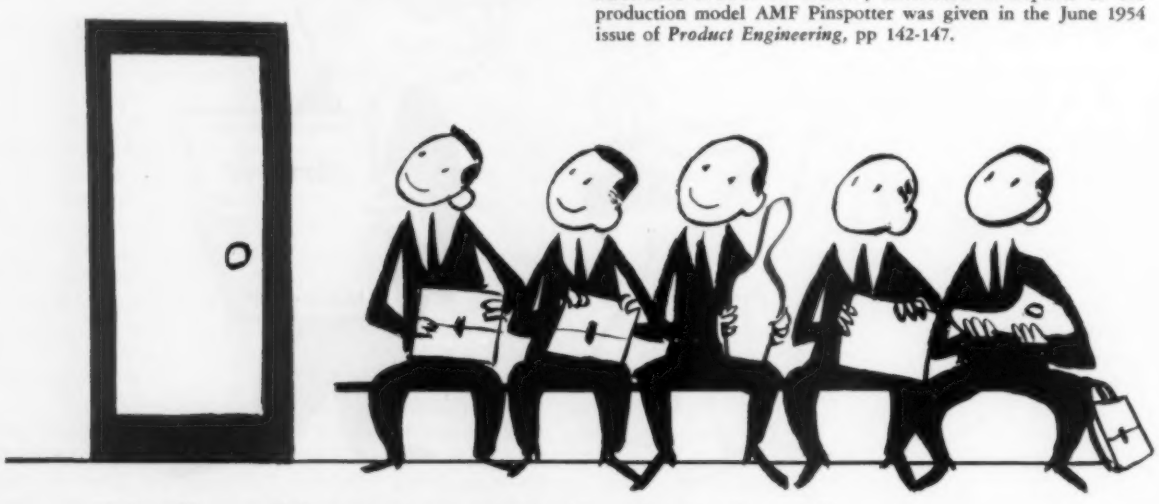
And even this is not the end of this success story of an invention.

The effect of this patented development was to stimulate more business and more jobs among a whole complex of suppliers. Steel wheels for lifting the pins are being stamped out for this machine at Youngstown, Ohio. Gear motors come from Fort Wayne, Ind. Electrical components from Chicago. Scores of Cleveland and other Ohio concerns supply parts and services. The main assembly plant, the service and alley personnel training center and the engineering center, employing several hundred people, are all located in Shelby, Ohio.

Because a whole new crew of salesmen were now going to bowling alley operations, it was decided to expand into other parts of the bowling industry. The pinsetter manufacturer started making bowling pins and bowling alleys, and a highly successful under-alley return for the balls was developed.

So because an engineer invented and was able to patent a single device for bowling alleys, an industry and a favorite American recreation has been revolutionized. In addition, the new bowling equipment manufacturer, a machinery producer, is today operating a maple forest and doing an excellent business in maple blocks.

EDITOR'S NOTE—A detailed, illustrated description of the production model AMF Pinspotter was given in the June 1954 issue of *Product Engineering*, pp 142-147.



"Finally, could patent protection be obtained . . .?"

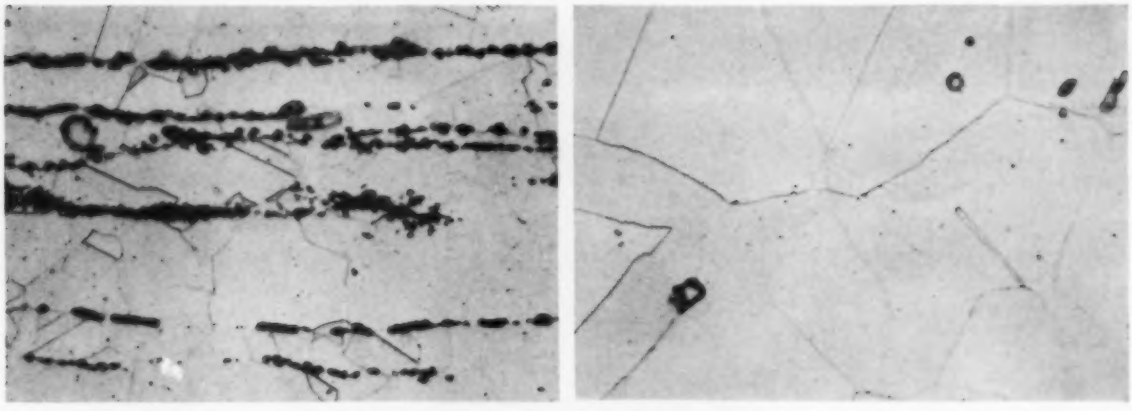


FIG. 1—Stringers of titanium compounds in air-melted alloy A-286 (left) produce discontinuities and reduce strength; clean material produced by vacuum melting (right) has higher mechanical properties.

VACUUM MELTED ALLOYS *for Forged Parts*

W. W. DYRKACZ,
Manager of Quality

E. E. REYNOLDS,
Associate Director of Research
Allegheny Ludlum Steel Corporation
Watervliet, N. Y.

Advantages and limitations of consumable electrode and induction heating processes; effect on cleanliness, segregation, and elevated temperature properties; relative costs and growing fields of use.

Table I—Composition of Some Superalloys

Alloy	C	Cr	Ni	Co	Mo	Ti	Al	V	Fe
M-252	0.15	20.0	Bal	10.0	10.0	2.5	1.0	...	5.0 max
Waspaloy	0.05	20.0	Bal	13.5	4.0	2.5	1.3	...	2.0 max
A-286	0.05	15.0	25.5	....	1.3	2.0	0.2	0.3	Bal

EARLY APPLICATIONS for vacuum melted alloys developed in jet engines where the advantage of higher performance justified the relatively high cost. Materials included the several superalloys listed in Table I. But greater use of vacuum melted alloys, and the increased capacity of recent additions to vacuum melting capacity (see box) together are beginning to reduce costs. Some heats have already

Consumable Electrode Process

been produced in tool and die steel, low alloy structural steel and a variety of stainless steels.

Two different methods of vacuum melting are used in producing these alloys, the consumable electrode and induction heating. In the induction process the metal is placed in a crucible surrounded by an induction coil, the whole being contained in a vacuum chamber. The procedure for melting is substantially the same as the one used in induction melting in atmosphere. This method has the advantage of allowing additions to be made to the melt, so that close composition control can be maintained. Disadvantage is that segregation is likely to occur on freeizng.

Commercial melting by the consumable electrode process has been carried on for years with materials such as titanium, zirconium, and molybdenum. Some modifications in the process were made in applying it to superalloys. Basically, the process consists of making cast electrodes of an alloyed, predetermined composition from a large, production-size, electric arc furnace air melt, and then

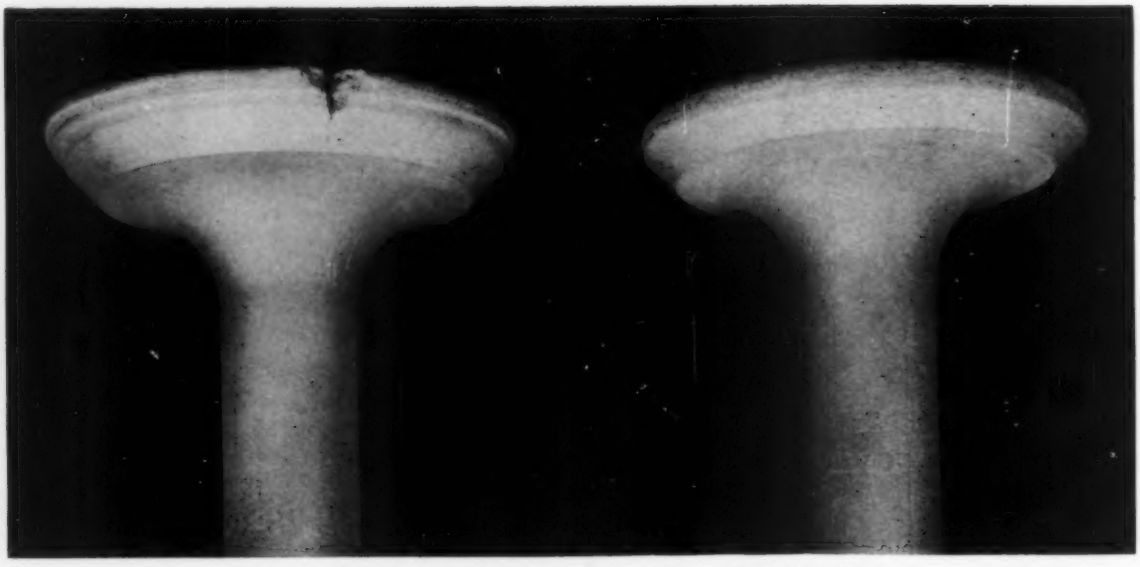


FIG. 2—Hot workability of metals is improved by vacuum melting. Valve forging of air melted G-157 at left; same metal vacuum melted at right.

remelting these electrodes under vacuum by arc melting in a water-cooled copper crucible. Vacuum melted [illegible] up to 12 in. in dia by 1000 lbs have been produced from Ni-base superalloys: up to 20 in. in dia by 5000 lbs in Fe-base superalloys; and up to 16 in. in dia by 2400 lbs in stainless and other steels.

Cleanliness

Remelting under vacuum by the consumable electrode process results in a large improvement in the cleanliness of the original air melted material, as shown in Fig. 1. Superalloys containing aluminum and titanium form oxides, nitrides and carbonitrides of these metals when melted in air. In the ingot these compounds produce typical "oxide folds" which later show up in finished rolled bars or billets as non-metallic stringers. As shown in Fig. 2, the presence of these discontinuities reduces the workability of the material, causing it to crack on the outer surface, especially on drastic upsetting. Vacuum arc remelting by the consumable electrode process substantially eliminates these non-metallic inclusions.

It is believed that cleaning of the air melted material during arc remelting under vacuum is accomplished by dissociation of the less stable compounds under the low pressures and high temperatures involved, since it is estimated that arc temperature is in the range of 8500 F. The more stable compounds, such as titanium nitrides, which have a lower specific gravity than the parent metal, float out and help the cleaning process.

Degassing

The breakdown of oxides and other compounds is accompanied by the evacuation of the liberated oxygen. By a similar process, the vacuum forces out of solution a large part of the dissolved gases which are likewise evacuated. Table II shows that vacuum melting by consumable electrode decreased the concentration of hydrogen, oxygen and nitrogen in three alloys by a minimum of 60 per cent and by as much as 94 per cent.

Freedom from Segregation

Because of solidification pattern, conventionally cast ingots are subject to segregation, which is most severe in the center and in the top third of the ingot. This segregation is particularly severe in materials containing high density elements, such as tungsten and molybdenum, and results in decreased tensile ductility at the center of the ingot, Fig. 3.

Melting in a cold mold by consumable electrode is characterized by a cooling pattern which allows only a relatively small pool of molten metal to exist in the mold at any one time, restricting migration of elements which results in segregation. Thus, mechanical properties at the center of the ingot are approximately the same as those at the periphery.

Table II—Decrease in Gas Content in Vacuum Melting by Consumable Electrode

Gas Analyzed	Alloy	Air (ppm)	Vacuum (ppm)	Decrease, per cent
Hydrogen.....	Waspaloy	17	2.2	88
	M-252	16	1.7	89
	A-286	13	2.8	79
Oxygen.....	Waspaloy	31	2.0	94
	M-252	15	6.0	60
	A-286	13	5.0	62
Nitrogen.....	Waspaloy	420	120	71
	M-252	160	40	75
	A-286	300	20	93

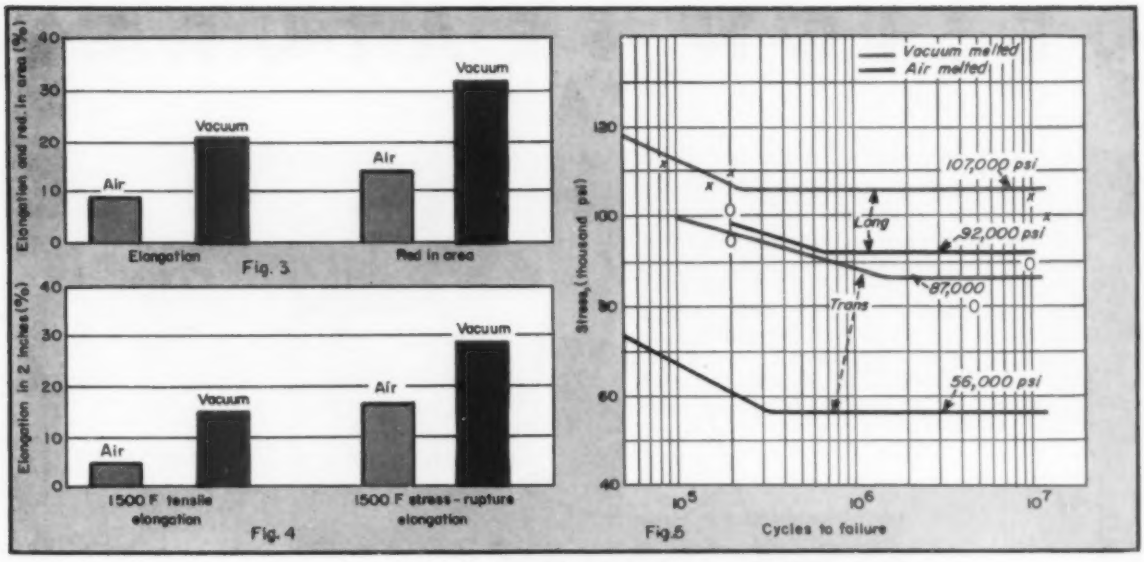


FIG. 3—Room temperature ductility of A-286 alloy is increased by vacuum melting. FIG. 4—Ductility of M-252 alloy at 1350 F and 1500 F is increased by vacuum melting. FIG. 5—Increased endurance limit of a vacuum melted SAE 4340 billet.

Improved High Temperature Properties

In common with induction vacuum melted materials, metals produced by the consumable electrode vacuum process exhibit an increase in high temperature properties over air melted alloys. Fig. 4 shows the improvement in hot tensile ductility of one alloy, but tests show that such other properties as hot fatigue strength and endurance limit at a given temperature are likewise improved, Fig. 5. In addition, vacuum melting affords the possibility of increasing the endurance strength by raising titanium content of titanium-bearing precipitation hardening alloys while still maintaining excellent hot workability. Increasing the titanium content in A-286 improves endurance strength at 100 million cycles and 1200 F from 37,000-45,000 psi to above 55,000 psi.

Consumable electrode vacuum melted materials are available as forging billets, extruded shapes, flat and round rolled bars and rods, tubing formed by hot extrusion followed by cold drawing, sheet and strip, and wire.

Due to their homogeneity and freedom from inclusions, metals and alloys produced by this process show improved workability in forging, upsetting and ring rolling; wire drawing can be carried to extremely fine sizes; and sheets can be rolled to very thin gages and subsequently worked successfully by standard procedures.

Future Process Refinements

Since vacuum melted alloys were developed to satisfy the demand for high purity materials, the only variety of these alloys available is "the best obtainable." The materials are sold to definite test specifications.

The relationship between amount of vacuum, rate of melting and mechanical properties of materials obtained has not been determined as yet.

Composition control by alloying additions is not readily feasible by the consumable electrode vacuum process, but is normally carried on by induction melting in a vacuum. A combination of the advantages of the two processes would involve vacuum induction melting to produce the electrode, which would then be remelted by the consumable electrode vacuum process. This technique will be explored in the near future with induction vacuum melted electrodes weighing 1000 lbs. Combining the two processes may result in obtaining an ultra high purity material but at added expenses.

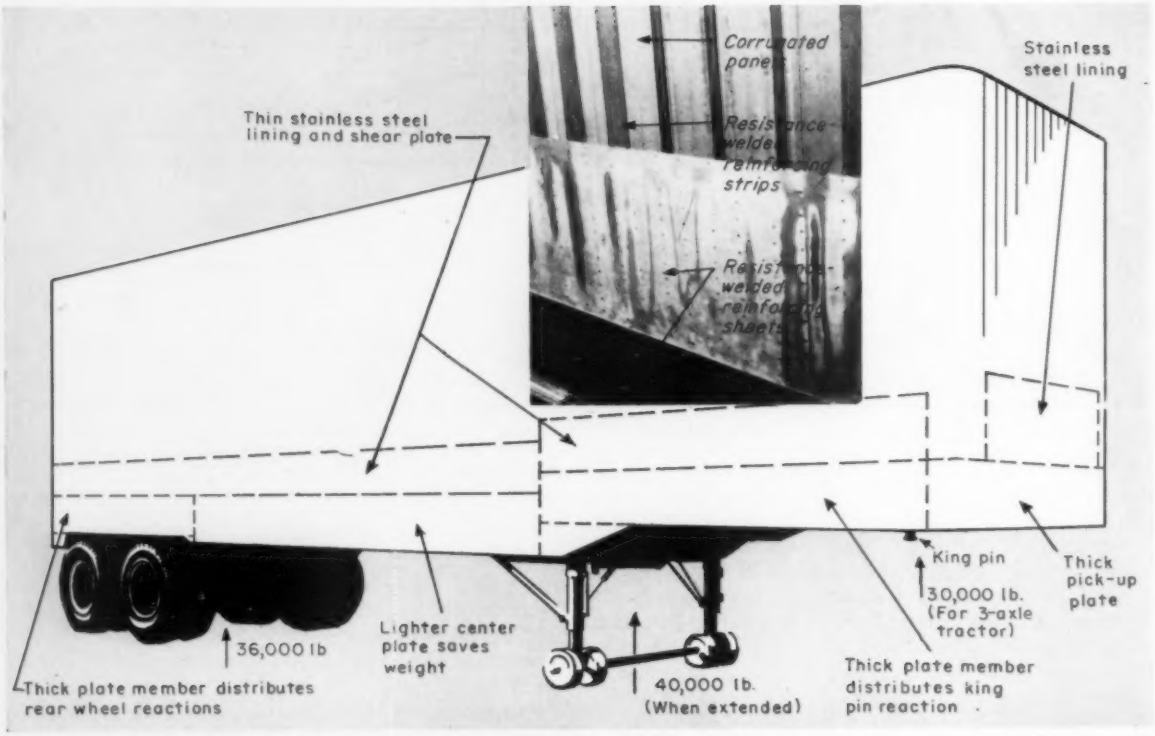
Costs

As a general rule, price of alloys remelted under vacuum by the consumable electrode process is from about fifty cents to one dollar per lb. above price of air melted materials.

New Applications

Increased availability and variety of consumable electrode vacuum melted alloys has stimulated their use on a development basis in such applications as special purpose springs, heavily loaded bearings, highly polished rolls, and dies and structural parts of large cross section which are made to very high tensile strength values. Additional applications and use on a production basis must await the coming into line of still larger vacuum alloy producing units.

Allegheny Ludlum monthly ingot production of vacuum melted alloys by the consumable-electrode process was 250,000 lb in December 1955, 500,000 lb in June 1956 and 1,000,000 lb by the end of 1956. In addition to this capacity, the company will have available a 2000 lb induction vacuum melting unit for commercial production in the near future. This plant is now completing a research and development program using a 300 lb furnace.


Corrugated panel
Resistance-welded reinforcing strips
Resistance-welded reinforcing sheets
Stainless steel lining
Thin stainless steel lining and shear plate
King pin
30,000 lb. (For 3-axle tractor)
Thick pick-up plate
Lighter center plate saves weight
36,000 lb
Thick plate member distributes rear wheel reactions
40,000 lb. (When extended)
Thick plate member distributes king pin reaction

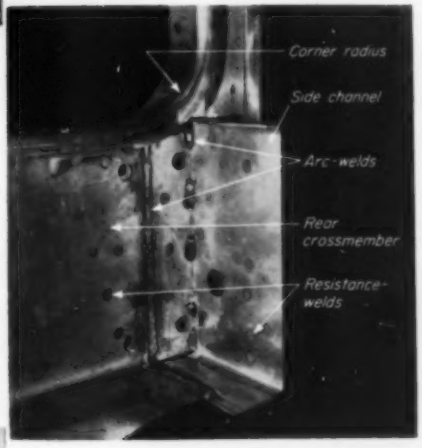
DEEP CORRUGATIONS on 6 in. centers make rigid box-section posts when reinforced by resistance-welded strips; intermediate, shallow corrugations increase resistance to local damage. Horizontal sheets, resistance-welded to the vertical sections, reinforce critical areas to increase strength and rigidity for stability under load. Previous trailer design used horizontally corrugated panels reinforced by "Z" shaped columns to obtain required rigidity. Columns added 1½ in. to wall thickness. New design uses no columns, but does use heavier gage metal and deeper corrugations to form the side panel sections. Extensive fatigue test programs under simulated highway conditions helped develop final design with high strength-to-weight ratio. Controlled resistance-welding technique joins parts without increasing weight and with no loss of strength or of stainless properties from precipitation of carbides. Individual welds in the stainless steel have tensile strengths from 450 to 6,000 psi, depending on metal thickness.

High-Volume Trailer Has Thin, Rigid Walls

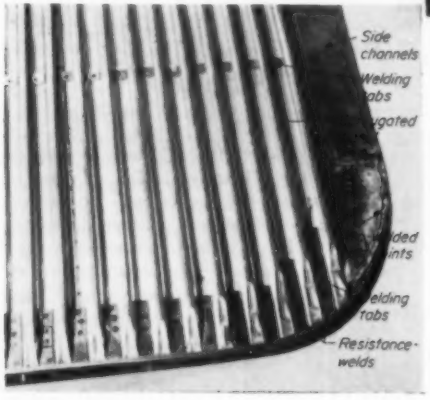
Redesigning side walls and rear doors of a Fruehauf trailer, to obtain greater strength and rigidity with thinner sections, has increased the internal volume. This meets trucker's demands for greater low-density payloads without exceeding legal limits on outside dimensions. Trailer's inside length is 4¼ in. less than its outside length; inside width is 94 in., with a 91 in. door opening, and an outside width of 96 in. Vertical corrugations in the side panels reduce required wall thickness by making separate column structures unnecessary. Designed and fabricated by the Budd Co., Philadelphia, Penna., the panels are made of stainless steel to obtain a high strength-to-weight ratio, and resistance to corrosion.

IN NEW PRODUCTS

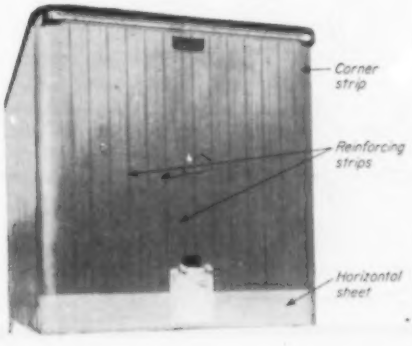
THREE METALS are used to build this trailer. Stainless steel is used for roof, side walls, reinforcements, and floor (not shown) for high-strength, thin sections with good corrosion resistance. Aluminum is used for floor cross members and supports, and for wheels to reduce weight. High tensile strength steel is used in the upper coupler, kingpin, front and rear under frames, and in the bumper for high strength and resistance to impact. Floors (not shown) are designed for concentrated wheel loads of lift trucks which handle palletized cargoes. Corrugated mat-type stainless steel panels are seam-welded into a one-piece floor section which will take wheel loads of 6700 lb. with cross members on 18 in. centers.



LARGE-RADIUS CORNERS prevent stress concentrations in rear frame which has been redesigned to get wider door opening by placing long dimension of door post lengthwise. Structural sections are assembled by resistance-welding with additional reinforcement at the corners. Last welds on inside of corner joints, at rear cross members, are arc-welded because space is limited. Assembly consists of door posts, roof header and gutter, and the rear cross member. Doors (not shown) have heavier framing with aluminum lining instead of plywood to reduce thickness from 1½ to 1 in.



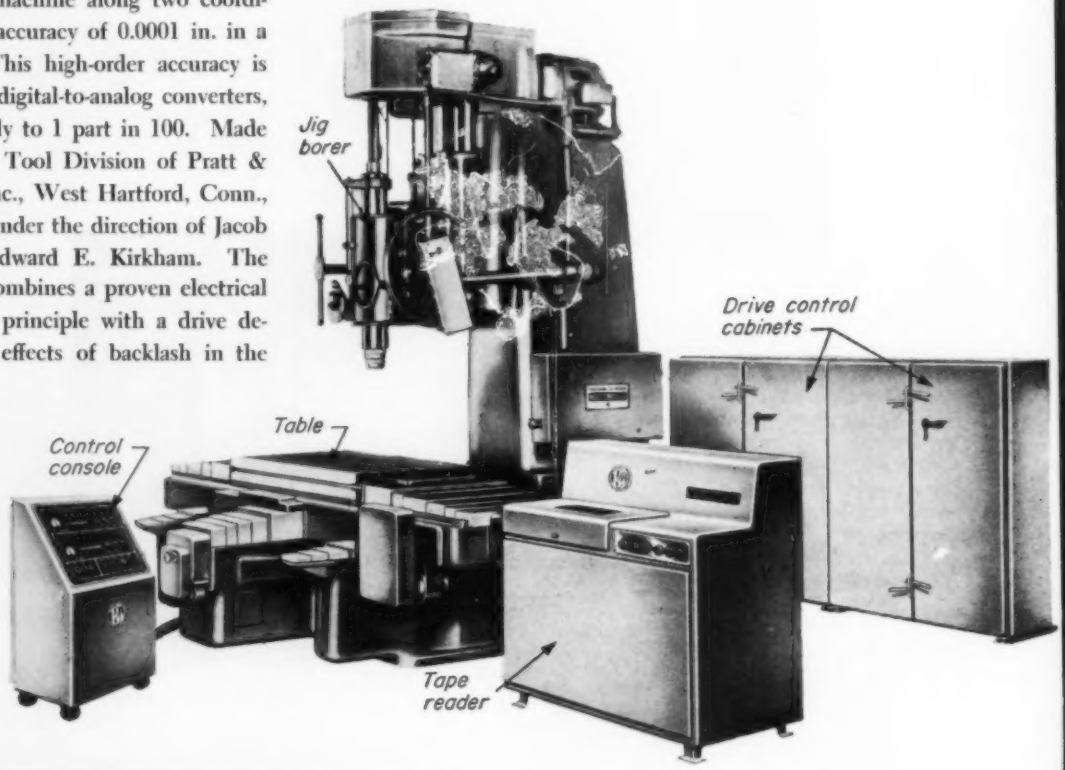
ROOF PANEL is formed of long strips of corrugated stainless steel seam-welded with overlapping resistance beads to make a one-piece, waterproof panel. The panel is then resistance-welded to internal cross members through pads which increase local strength at the weld to resist stress concentrations from vibration strains. Butt joints in side angles are arc-welded for high tensile strength. Ends of corrugated panels are crimped and folded between end angle and inside reinforcing strip, then resistance-welded.

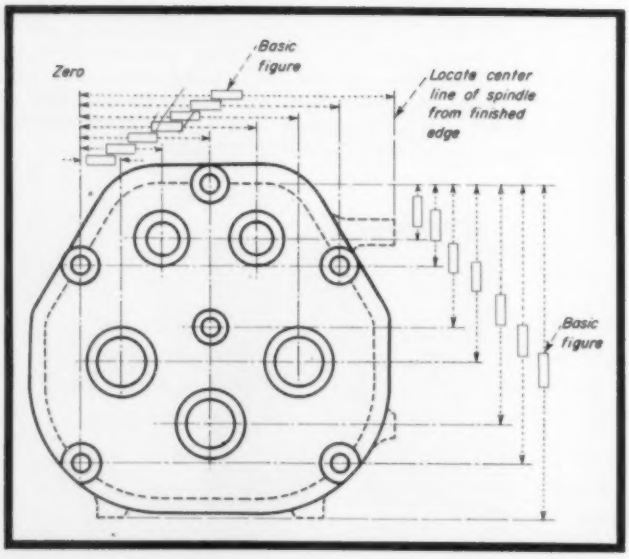


FRONT END SECTION has corrugations on inside with vertical reinforcing strips and horizontal reinforcing sheeets resistance-welded to the outside surface. This design reduces wind resistance and makes a smoother outside surface. Wide curved strips reinforce each corner radius. Section includes front cross member and is arc welded to roof and side panels.

Numerically Controlled Jig Borer

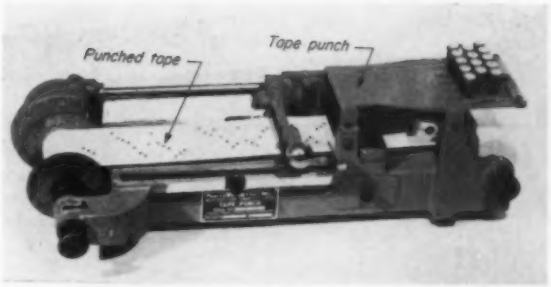
Drawing data, stored in a punched tape, automatically positions the table of a vertical jig boring machine along two coordinate axis, to an accuracy of 0.0001 in. in a 60 in. travel. This high-order accuracy is obtained with 3 digital-to-analog converters, each accurate only to 1 part in 100. Made by the Machine Tool Division of Pratt & Whitney Co., Inc., West Hartford, Conn., it was designed under the direction of Jacob J. Jaeger and Edward E. Kirkham. The control system combines a proven electrical position sensing principle with a drive designed to avoid effects of backlash in the lead screws.

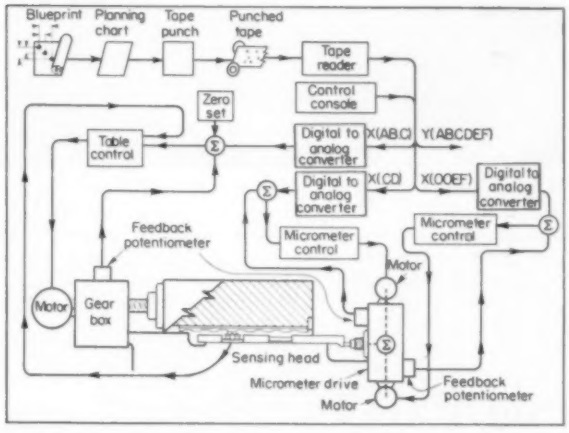




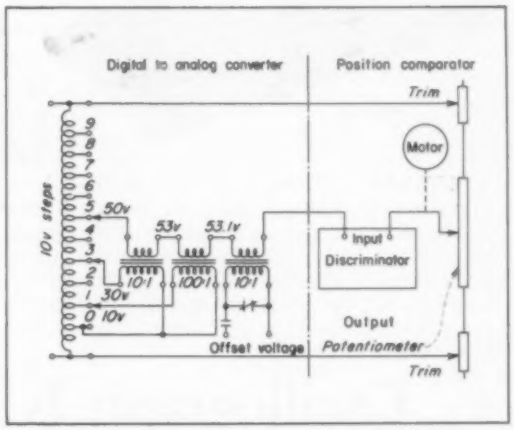
NUMERICAL CONTROL can be applied only to machine tools constructed with accurate coordinate axis from which measurements can be taken, and which have an adequate position measuring system. Basic jig borer included these elements in the manual positioning system which used a measuring bar with accurately positioned magnetic lugs at 1 in. intervals; an inductance bridge circuit having a sensing head detected the magnetic centerlines of the lugs. Table was positioned manually to the nearest inch, then a micrometer screw offset the sensing head to add distances less than 1 in. To develop the automatic numerical control system, methods had to be selected to store and handle digital data, to convert it to analog form, and to drive the table to an accurately measured position. Punched holes were found preferable to magnetic or optical storage methods because simpler equipment can read the data. Existing punched hole record systems were examined and abandoned as not suitable for shop use, and because cost was too high; equipment was then designed specifically for machine tool use.

PAPER TAPE was selected instead of cards as handling mechanism is simpler, and tape may be automatically rewound, while cards must be returned to the feeder by the operator to start a new cycle. Plastic tapes are used for applications requiring excessive handling. A wide tape is used to keep information density low to avoid reading errors from variations in tape size or position. Accurate longitudinal hole spacing is obtained by using a tape punch having a moving carriage, like that of a typewriter. Tape is clamped just before block signal hole is punched, and numerical data is inserted as the carriage is spaced by a rack and escapement; data is stored in 12 longitudinal rows. Ten rows are for digits 0 to 9, one row is used to position each block of information, and one row is used for rewind signals. Air forced through holes in the tape actuates diaphragm-operated limit switches to convert the data to an analog voltage. Tape is held stationary, while data is read and the machine positioned, to avoid using buffer storage. ▶

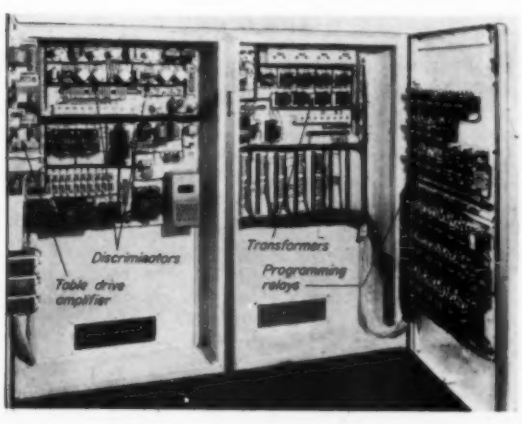




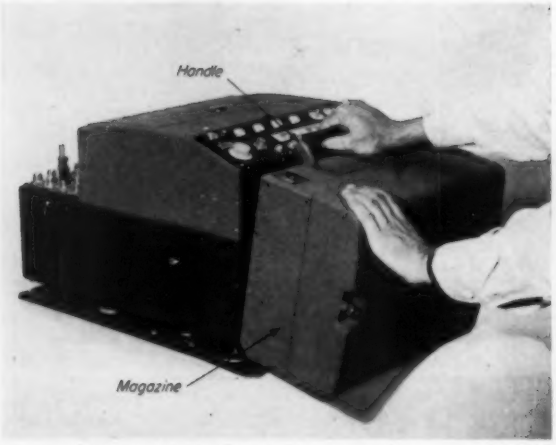
AN ANALOG VOLTAGE proportional to magnitude of digits represented by punched holes is tapped from an auto-transformer by pneumatically operated switches in the tape reader. The autotransformer has a distinct advantage over 2-winding transformers as phase shifts, caused by leakage reactance, in one section of the winding are offset by identical effects in the other section; phase shifts will produce an imperfect null at the balance point. Voltages representing sum of digits processed in each converter and an offset voltage are fed to a discriminator which compares it to the voltage fed back from a helical potentiometer geared to the table drive screw. Discriminator output operates the multispeed gear box to position table. Successive sets of digits position the sensing head in a similar manner.



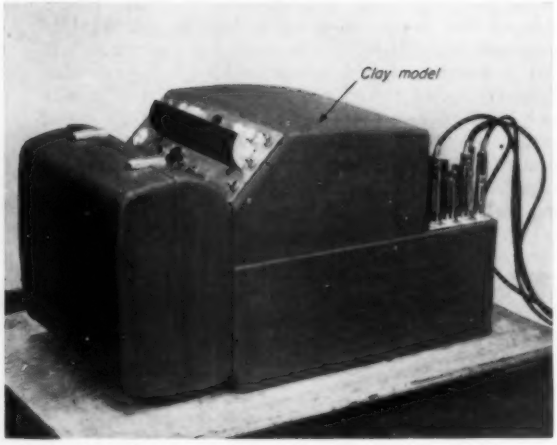
MEASURING SYSTEM uses 3 digital-to-analog converters to position the table. If a single converter was used, its accuracy would have to be 1 part in 600,000. Practical approach was to solve the conversion problem by using several lower accuracy converters with proper bench marks to refine the accuracy as the successive settings are made. Adding suitable feedback drives adapted the existing measuring system to numerical controls. Table is positioned approximately by first 3 digits (AB.C), with a potentiometer in the table drive producing the feedback signal. Motors actuated by last 2 converters drive micrometer screw through a differential to position sensing head between the magnetic benchmarks. Signal from sensing head then actuates table drive to align itself with next benchmark to set final position.



FINAL APPROACH VELOCITY is permanently programmed in control system so setting is always made in the same direction and at a series of preset speeds. A 4-speed drive is used with an overall ratio of 2500 to 1. Drive controls for each axis are in two-section cabinets. Amplifier which converts sensing head signal to a relay signal, and discriminator for the table drive are on the left door. Left cabinet section holds discriminators for micrometer drive and the power supply components. The autotransformer and the stepdown and offset transformers are in right cabinet section; programming relays are on the right door. Unit is built to J.I.C. standards. ◀

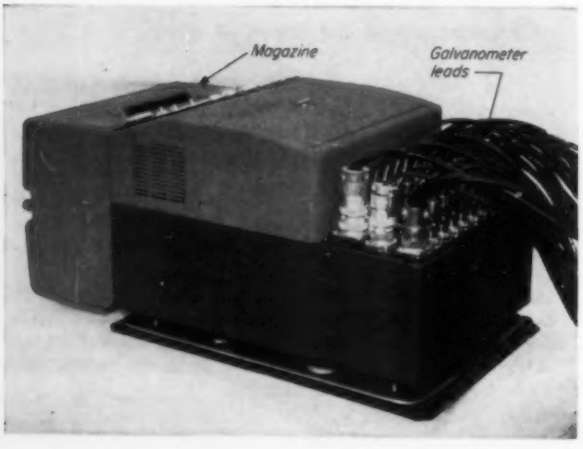


INDUSTRIAL DESIGN placed emphasis on hand and arm motion required to attach and remove the magazine. Handle on top is not only used to lock the magazine in place and open the spring-loaded shutter; it serves as a carrying handle when magazine is removed from oscillograph. Operator convenience as well as performance was a major factor in design of the instrument. A clay model was made to help obtain agreement on general styling and the placement of controls. Then, mechanical assembly layouts were started which served as major reference drawings throughout the design program. Full scale drawings were used for quick visual judgment.



Oscillograph Is Designed To Order

Planned procedures guided the design of this oscillograph from initial market survey to final prototype tests. Designated Type 5-119, it is made by Consolidated Electrodynamics Corp., Pasadena, Calif. Following a market survey, teams of project design and field sales engineers visited key users to determine exact requirements. Service records of past designs, technical literature, and research engineers also helped set up tentative specifications reviewed by the design committee. Once approved, the program was put under the supervision of a project engineer, assisted by designers, draftsmen, and a project technician.



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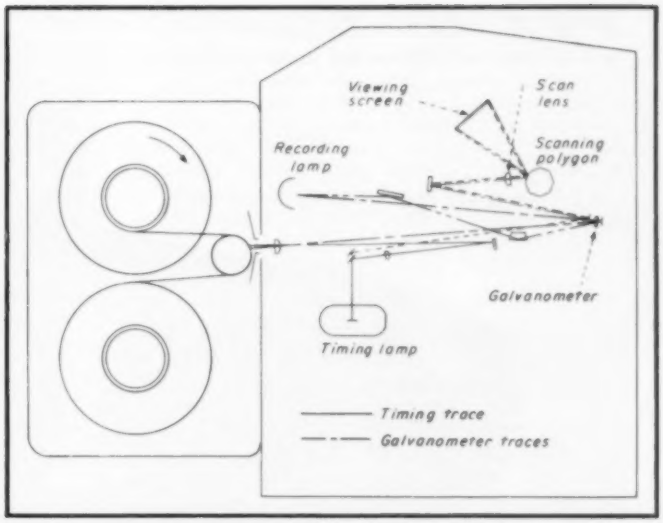
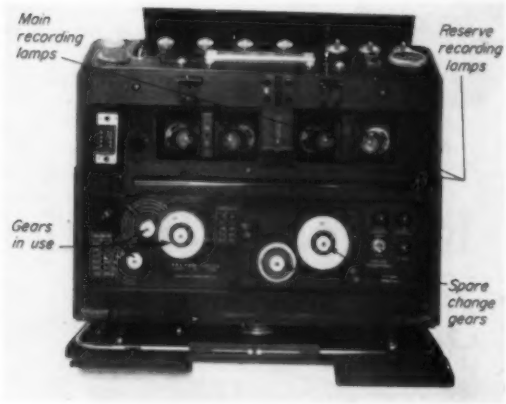
LEADS to the 10 recording channels and to the power supply are brought in at rear through a compact connector board. The design team recognized that the electrical designer can shift components and wiring to fit allotted space, but the mechanical designer has to fix his layout almost as soon as he begins his design, as physical arrangement is critical in mechanical assemblies. Layout work was started when development testwork indicated the most promising design approach, and each problem was broken down into functional parts. Solutions to each problem were assembled and studied. Functional mockups of more than one approach were made in some instances to speed selection of the best solution.

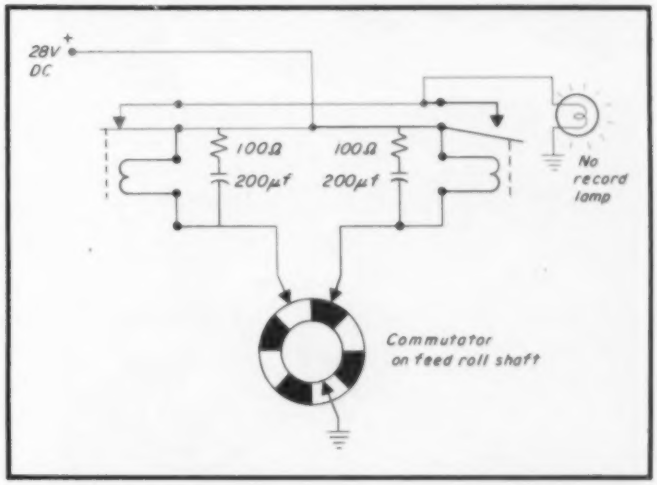
OPTICAL SYSTEM uses tungsten-filament lamps to obtain adequate light for high-frequency recording combined with sharp trace definition. To prevent loss of record in event of lamp failure, a current relay in series with each main recording lamp changes to a reserve lamp automatically. Lamp brilliance is varied with recording speed to keep recording densities uniform. Photographing an event number, in addition to a record number, for time correlation with other data, requires short exposures to prevent blurring of the numbers at high paper speeds. A small gas-filled flash tube was selected to meet exposure time requirements with adequate light intensity for good recording. The flash tube and its ignition transformer are encapsulated to prevent arc-overs at high altitudes.



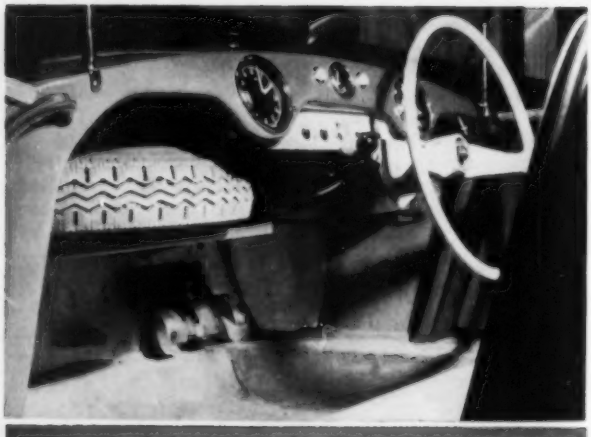


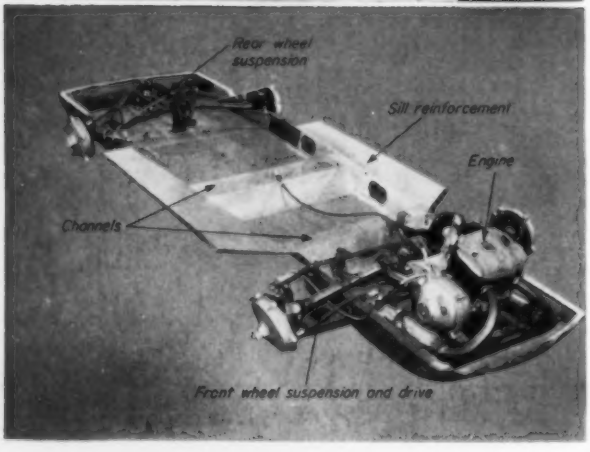
RECORD DRIVE uses a 16-step change-gear transmission to obtain a speed range from 0.1 to 100 in. per second. Gears are changed on front of instrument by manually pushing them in place on the shafts. Gears not in use are stored on dummy shafts at right of transmission panel. An electrically operated jump-speed clutch, in the transmission, changes record speed by a 10 to 1 ratio to spread or compress wave forms for increased clarity. Combined with galvanometer responses up to 5000 cps, this speed range provides clear records for a wide variety of phenomena. To maintain dimensional stability with large temperature changes, the transmission housing is a Meehanite casting; pitch diameter tolerances were considered critical to reduce backlash and prevent tooth interference at temperature extremes. Also, helical gears are used to reduce noise and vibration. Change gear pairs consist of a steel gear meshed with a nylon or cotton-filled phenolic resin gear to avoid lubrication problems.

EXHAUSTING THE PAPER SUPPLY is a main cause of failure to record in present-day oscillographs. "No record" warning circuit is based on supply roll rotation so stoppage for any reason is brought to operator's attention. Problem was to design a warning device which would be dependable over the wide range of supply roll speeds. Solution adopted was 2 parallel relay circuits energized through a commutator on the supply roll, with capacitors to maintain current flow when the brushes are moving between segments. If the roll stops, a relay is de-energized and the warning lamp glows within 1 second. Also, if the reserve lamp in the optical system fails in use, this same lamp is energized by another circuit.



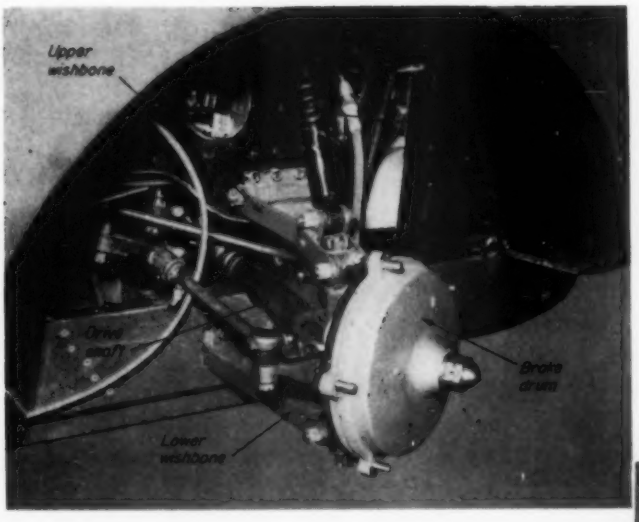
Plastic moldings assembled with light gage aluminum stampings are the structural components of this sports car made by Berkeley Coachwork Ltd., Biggleswade, Beds, England. The stressed skin body and frame construction, with aluminum alloy bulkheads and crossmembers, forms a rigid unit having a high strength to weight ratio. Body is molded in 7 sections. The car weighs 616 lbs., is 10 ft-3 in. long with a 5 ft-10 in. wheelbase, and cruises at 60 mph. Fabrication requires semi-skilled labor and simple jigs.





Reinforced Plastic Shell Forms Car Frame

DISHED PONTOON SHELL, which is largest molded component, forms underside of body, and door sills. Stamped aluminum alloy channels reinforce the highly stressed center section, providing all resistance to bending and most of the torsional rigidity. Fiberglass reinforced shell of the car serves as a skin, and prevents local buckling in thin walls of the load-carrying stampings. Sill areas are covered with "L" shaped stampings to form a rigid box structure. Cross members have a "U" shape. All stampings have flanges for riveting them to the plastic pontoon. Steel plates, molded into the shell, reinforce areas subject to concentrated loads. Channel shaped longerons, riveted to front cross member and to the pontoon, carry the 3 engine mounts. The transverse channel also supports lower wishbone hinges of front suspension. Aluminum box sections, molded integral with hood and tail sections carry wheel and engine loads and are bolted to the pontoon through mating side flanges.



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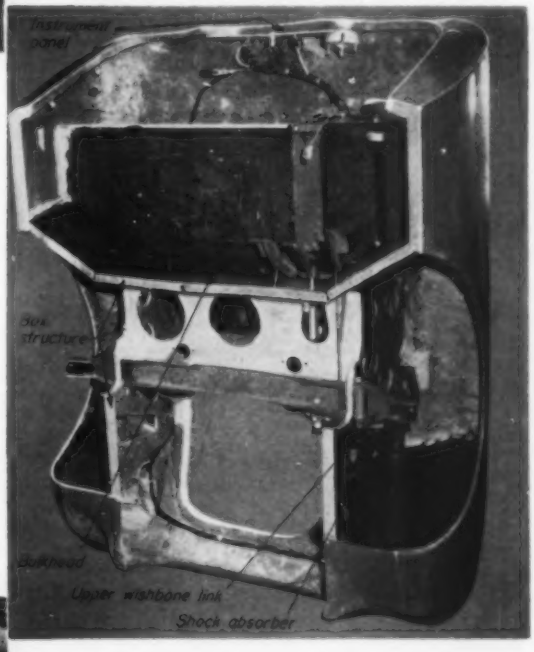
ALL WHEELS are independently sprung. Front wheels are supported by unequal length wishbones from a transverse channel on the pontoon and side walls of aluminum box structure in hood, with combined coil spring and shock absorber units. Rear wheels are supported by triangulated swing axles hinged to the pontoon at car's centerline. Rear coil spring and shock absorber units are mounted in a well between the seat bucket and the metal wheel wall. Shock absorbers are anchored on trunnions bolted to a wide steel gusset plate which is anchored in the plastic.



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HOOD SECTION is formed around an aluminum box structure which has an extended side at each corner bonded into the fiberglass shell. Edges of extensions are perforated and laced with glass tape to make a high-strength mechanical bond. Rear end is closed with a bulkhead which rests on the front pontoon transverse channel; sides are riveted to the engine support longerons. Wheel reactions are transmitted to the structure through anchor points, in the side of the aluminum box structure, which carry the upper wishbone hinges. The molded hood shell is riveted to the pontoon along the flanged edges. Tail assembly is made in a similar manner, but has less reinforcement.

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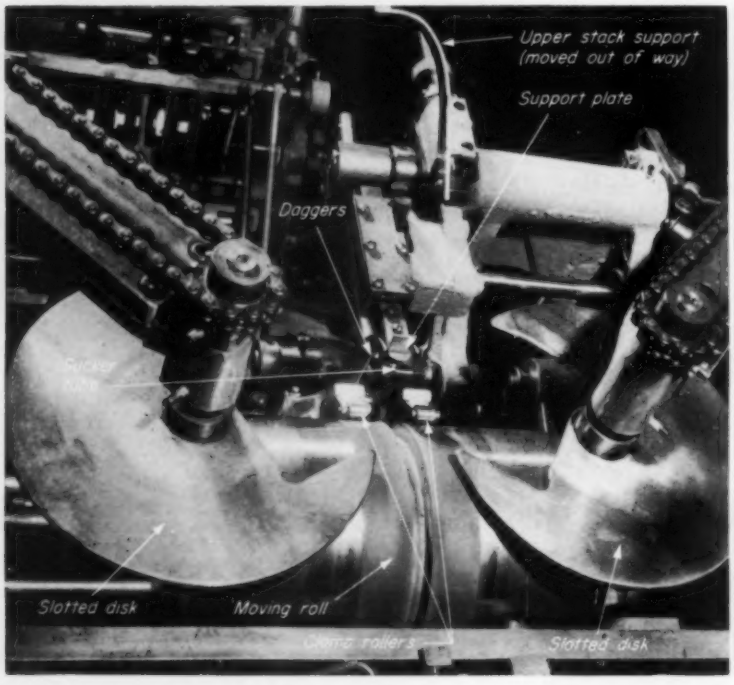
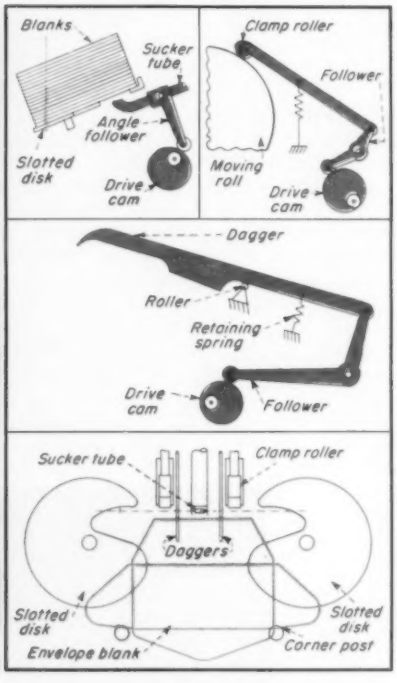
AIR-COOLED ENGINE is special Excelsior 2-cylinder, 2-cycle unit which develops 18 bhp at 5000 rpm. Front wheels are chain driven through a differential and gear box integral with engine; the gear box provides 3 speeds forward, and 1 in reverse. Horsepower-to-weight ratio is 65.5 bhp per ton. Car cruises at 60 mph, has a top speed of 75, and goes 70 miles on a gallon of gasoline. Roll axis is so close to center of gravity that very little rolling moment develops when cornering at high speeds.

Suction Pickoff Feeds Blanks To Envelope Machine

Die cut paper blanks are pulled from the bottom of a stack by an oscillating suction tube, and positioned on a moving roll, to form a continuous overlapped stream which is fed into an envelope machine made by the F. L. Smithe Co. of New York City. In this shingled position, the blanks are seal gummed and dried, and then carried to seam gumming and folding stations. The feeder combines timed motions of separating and supporting mechanisms with that of the suction tube to accurately position 200 to 500 blanks per min.

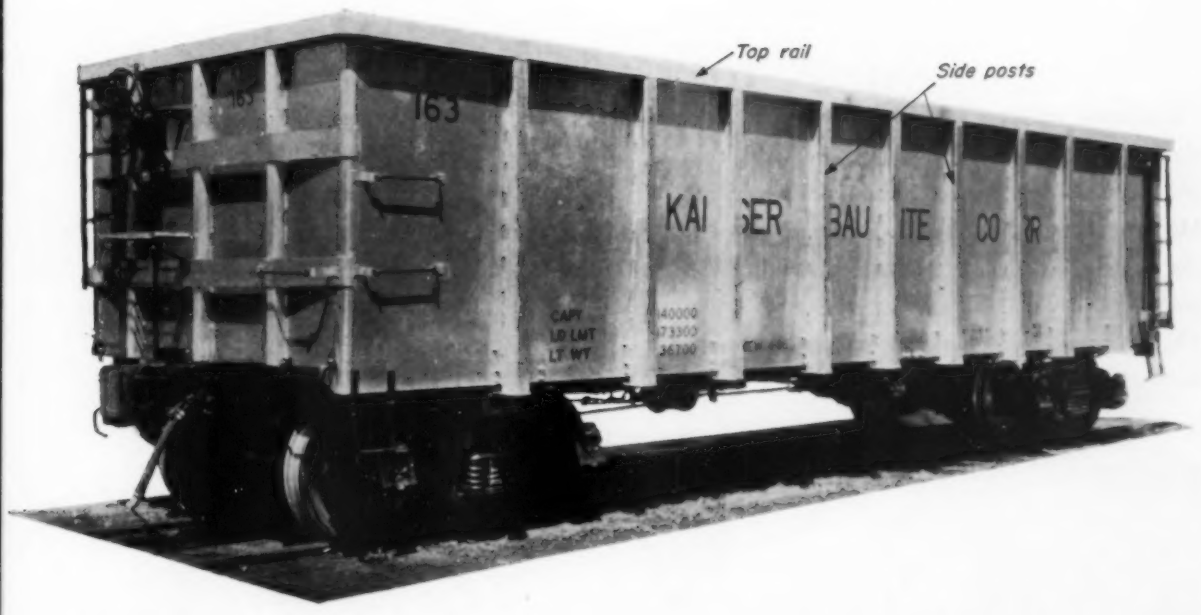




FEEDING SPEED varies with size of envelope. Very small envelopes are folded and sealed at 200 per min, while medium and large size envelopes are handled at rates up to 500 per min. This feeder is designed to handle blanks for open end envelopes from 1½ by 1½ in. to 4¾ by 5 in., and 1½ by 1½ in. to 3⅛ by 5½ in. for open side envelopes. Stacked blanks are supported by 2 notched disks and a separator plate, with front ends held high to keep stack aligned against rear corner posts. Friction between bottom blank and rotating disks also keeps stack against the posts.

Blanks are positioned on moving roll by the following sequence or motions. Sucker tubes moves upward to support the stack, and bends the tip of the bottom blank down as the separator plate moves back. Then the separator returns to support the stack again while the sucker tube starts to move down, carrying the bottom blank. Two daggers then move forward over the blank and push it down on roll. Simultaneously, noses of the rotating disks move between this blank and the stack, and clamping rollers move forward over edge of the blank. Friction of moving roll and previously fed blanks pulls blank through slots in the disks and into moving stream fed to the envelope machine.

Four cams on a common horizontal shaft program the feeding motions. Three of these cams drive the reciprocating elements, while the fourth controls the suction air valve. A separate cam on a vertical shaft moves the separator plate. Sucker tube, daggers, and clamp rollers are driven with angle followers. Daggers ride over guide rollers and are given a vertical motion component by their shape, which serves as a built-in linear cam.



TWO BUTT-WELDED $\frac{3}{8}$ in thick plates form a continuous side which is assembled on a bench. Top rail is a single extruded section. Extruded side posts fit into top rail and are welded to it and to the outside of the side plates on 3 ft centers; inert-gas arc welding is used for all joints. Tapered side posts are made by cutting webs of extruded 12 in. I-beams. Flanges are reinforced with $\frac{7}{8}$ by 4 in. plates to make posts flush with side rail on the outside, and to obtain rigidity required in various unloading attitudes when the car is in the rotary dumper. Sides slope outward at a 2 deg angle to facilitate gravity dumping.

Side and end sill angle is a 6 by 4 in. extrusion welded to side, end, and floor of the car body. Each end has 3 extruded vertical posts welded to the end-plate, and is reinforced, in addition, by two $\frac{1}{2}$ by 6 in. horizontal straps welded to end posts and corners of the car. Floor is made by butt welding four $\frac{7}{8}$ in. thick plates into a single piece; drain holes are drilled in each section to prevent the accumulation of moisture.

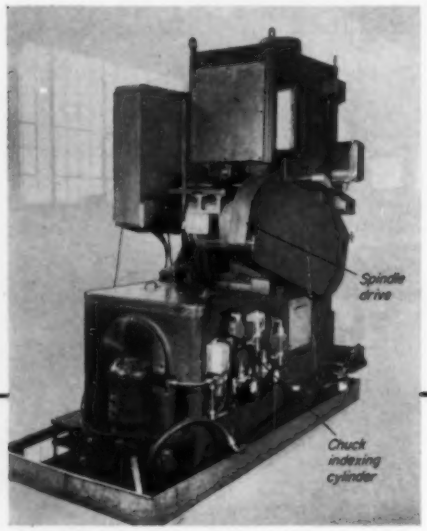
Car body is joined to underframe with hot driven rivets which pass through side sill angle, floor plate and diaphragm. An aluminum gusset, welded to the bottom of each post, fits around the diaphragm or cross beam to make a rigid floor section. Underframe is a standard AAR type and is assembled to the body in simple jigs. Areas where steel and aluminum are in contact are protected with zinc chromate paint on the aluminum, and a non lead bearing primer on the steel. Underframe is sprayed with a car cement. Coupled length of car is 40 ft, 9 in., while inside dimensions are 36 ft, 5 in. by 9 ft, $6\frac{1}{2}$ in.; body is 6 ft, 5 in. high. Weight empty is 36,700 lb, and payload capacity is 173,300 lb.

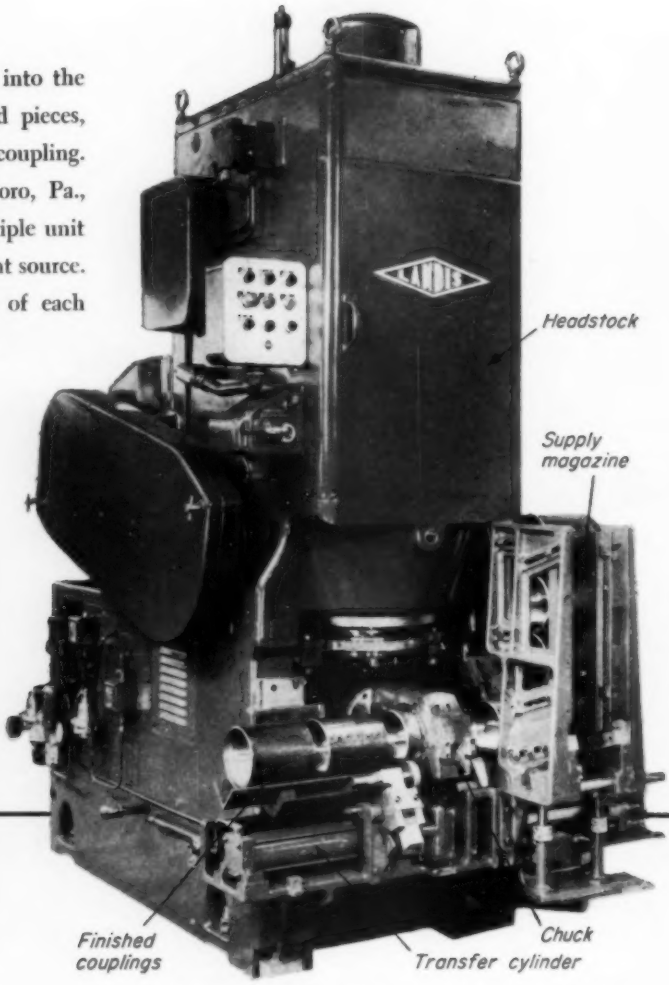
Welded Aluminum Freightcar Carries Heavier Payload

Thick aluminum plates, welded to extruded structural shapes, form the body of a gondola car which carries a 20 per cent heavier payload than its all steel predecessor. Extra load is carried on same 70-ton steel trucks without exceeding AAR limitations. Designed jointly by Kaiser Aluminum's Product Development Department and Magor Car Corp., Clifton, N. J., the cars haul bauxite from a mining area on the island of Jamaica to ships. The aluminum body resists corrosion by the marine atmosphere without painting, abrasion by the bauxite to give a long service life, and severe structural strains when overturned to dump its load.

PRODUCT DESIGNS

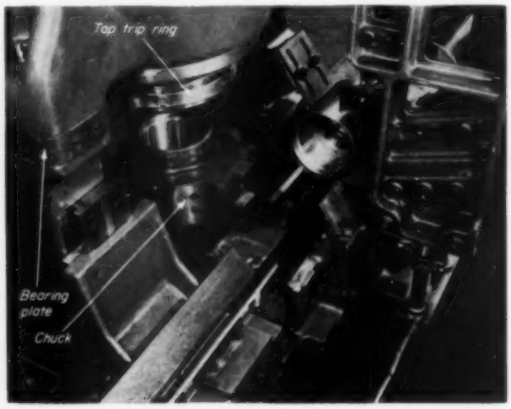
Pneumatic cylinders feed pipe couplings into the chuck from a magazine, discharge finished pieces, and position chuck to tap both ends of each coupling. Made by Landis Machine Co., Waynesboro, Pa., the machine is designed to operate in multiple unit gangs, with air obtained from a common plant source. The operator merely loads the magazine of each machine and removes the finished pieces.





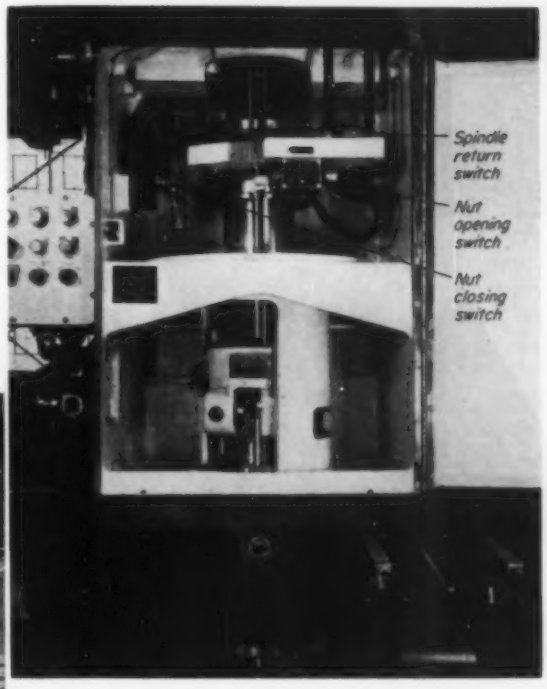
CHUCK is positioned for loading and tapping operations by air cylinders at rear of machine. An air cylinder on front of machine moves couplings in and out of the chuck. Cycle starts when transfer moves coupling into the chuck, positioning it with an automatic workstop. Chuck drum then moves back from loading position and indexes 90 deg to bring coupling into tapping position. A lock bolt prevents drum motion during the tapping operation. Spindle and tap head unit then drops to perform threading operation, but is decelerated by a hydrocheck before contacting the coupling.

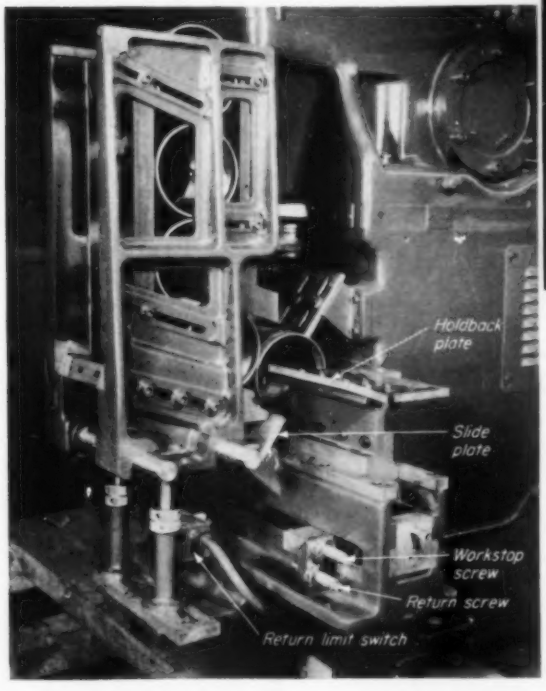
HEADSTOCK floats on linear ball bearings so tapping spindle is self-aligning when it enters the coupling. Machine bed is open below the chuck, and sets over a coolant and chip collecting pit built into the foundation. Once the lead screw nuts have engaged, tap-trip ring and collapsing cam-collar unit stays in contact with the coupling throughout the tapping cycle. Tap-spindle unit actuates a chaser receding mechanism, as it passes through the cam collar, to control the thread taper. The tap collapses when proper thread length has been reached, and the spindle returns to its upper position. Chuck drum indexes 180 deg, and the cycle is repeated. When both coupling ends are tapped, chuck moves to loading position and finished coupling is pushed from the chuck by the one being loaded.



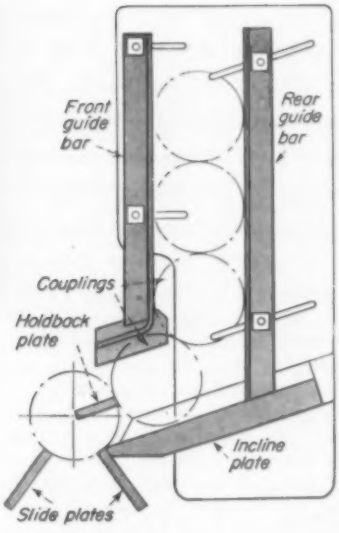
Transfer Mechanism Automates Pipe Tapping Machine

ELECTRO-PNEUMATIC CONTROLS sequence operations of the automatic cycle as each operation trips a track switch to sequence the next motion. Switch at upper left corner, inside headstock, closes the lead screw nuts when spindle reaches coupling, turns on coolant, and exhausts air cylinder which lowered spindle. Center switch, which operates at end of tapping operation, shuts off the coolant and opens lead screw nuts so the spindle can be raised. Switch at upper right, which closes when spindle returns, disengages the chuck lockbolt and readies unit for next tapping sequence.



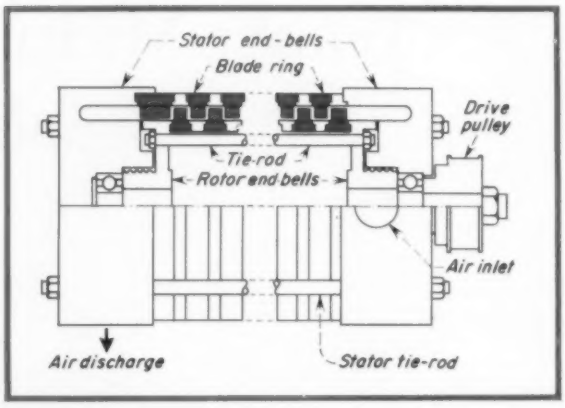


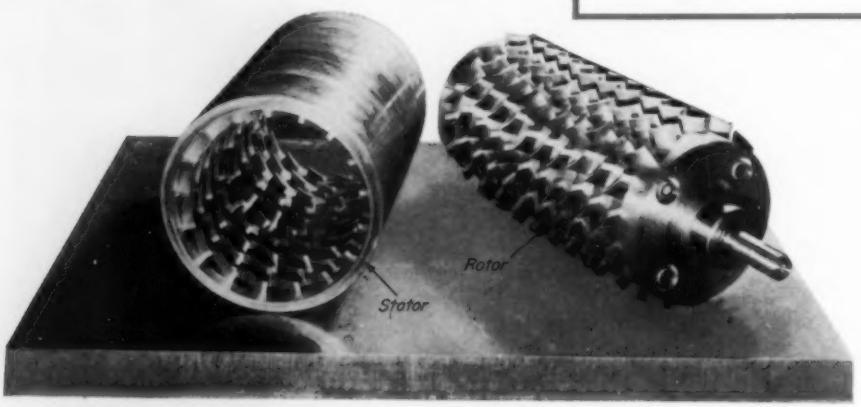
COUPLINGS feed by gravity from magazine to slide plates of transfer mechanism. This unit is adjustable and handles sizes from 1¼ in. OD upset tubing to 6 in. OD casing pipe. As the air cylinder pulls a new coupling into the chuck, the holdback plate keeps next coupling in place in the magazine. Coupling is centered in chuck by stopping the transfer motion with a workstop screw which butts against the frame. At the same time, a second screw actuates the return limit switch, and transfer unit moves back to receive the next coupling.



PARTS which change in size or position when OD of coupling is changed. Holdback and slide plates must be replaced with plates which will align the coupling with center of the chuck. Incline plate is positioned so couplings roll into position on the slide plates, and vertical guide bars are positioned so couplings feed properly. Magazine is also adjustable for coupling length.

AIR ENTERS right-hand stator end bell through carburetors (not shown) on each side at the centerline, and is distributed to the annular passage through the blades. It is collected at the left-hand end bell and discharged down into the engine intake manifold. Ring assemblies of rotor and stator are clamped with axial tie-rods which lock blades in place. Stub shafts pressed into the rotor end bells are supported by ball bearings in the stator end bells. To prevent distortion from thermal expansion, all parts except the bearings are made of the same metal, and are machined from rolled stock; no castings are used. Although efficiencies of 90 per cent were obtained in an 11-stage unit using finer blade pitch toward the discharge end, the production model has fixed blade pitch to lower the cost. This lowered efficiency to about 70 per cent, which is still satisfactory.

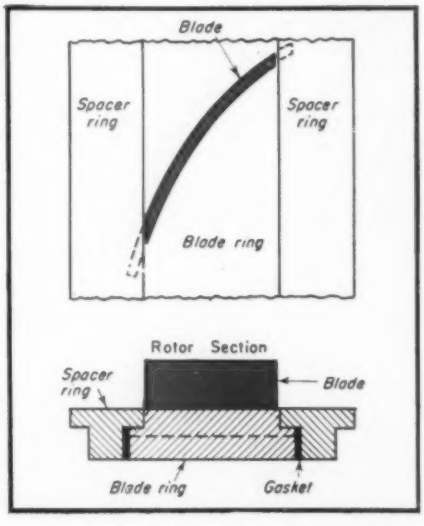




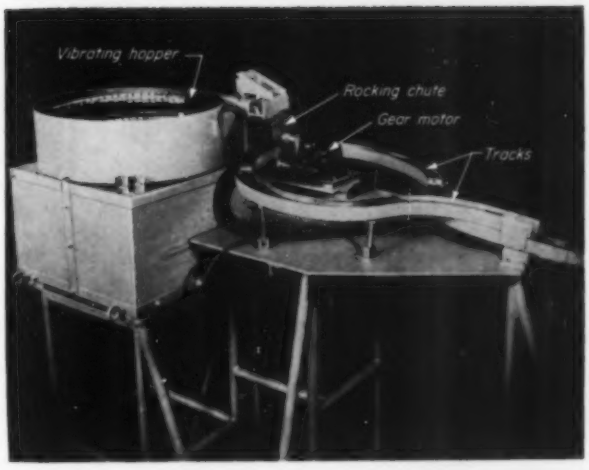
Compressor With Modular Construction

Rotor and stator of this axial flow compressor are assemblies of interlocking blade and spacer rings of similar cross section and diameter. Made by Latham Manufacturing Co., West Palm Beach., Fla., its construction is particularly adapted to low cost production with simple tooling. Although now used only for engine supercharging at low pressures and flow rates, developments are underway for gas turbine applications.

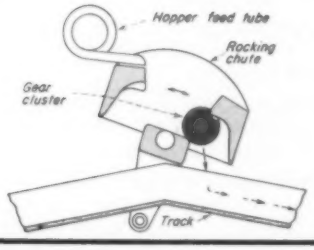
BLADES ARE FORMED from high strength sheet aluminum in a die punch, with all dimensions except thickness in excess of finished size. Slots milled in the blade rings are the same width as the blades, and have the same curvature. Blade ring shoulders are turned to finish size, along with the blades, after blades have been pressed into the slots. As shoulder surface is above the bottom of the blade slots; this forms a tongue in each side of the blade which fits under the "T" shaped spacer rings. When rotor, or stator, is assembled, blade and spacer rings butt together at the shoulders to maintain axial alignment. The sharp leading edge, produced when the blade is machined, reduces turbulence and gives non-surging operation over a wide speed range.



CHUTE ASSEMBLY is mounted below hopper discharge tube and is driven by a gearmotor through an eccentric and connecting rod. Each side of chute has a passage to circular tracks, with a probe which fits groove between the pinions. Probes are offset axially to sort clusters on basis of their orientation when they emerge from the hopper. Circular tracks discharge clusters to the gear speeders with same orientation. Gear orienting unit was designed by Michigan Tool Co., Detroit, Mich., for use with their model 1126 gear speeders.



Rocking Chute Orients Gears For Test



Production gear speeders are set in line to sound test each gear of a 2-gear cluster as it is fed from a vibrating storage hopper. As face widths of pinions differ, cluster must be oriented so each gear is tested by the correct speeder unit. Passing gears through a rocking chute lets them select either of 2 circular paths so they come to the test stations in proper order.

Overfill of liquids in canning and bottling machines is reduced by a control unit made by Crown Cork & Seal Co., Philadelphia, Pa. Volume delivered is changed with product temperature according to a predetermined density-temperature relationship.

Removable plastic molds which are automatically lined with foil wrappers are used in a cream cheese packaging machine made by Marathon Corp., Menasha, Wis. An electric eye prevents the molds being filled when no wrapper is present.

Investment casting a body block for a high speed can making machine saved 60 per cent of the time required to machine it from a solid stainless steel bar at American Can Company.

Nickel alloy cast iron brake linings, bonded to cast aluminum drums are used in Daimler-Benz cars to resist warpage and wear.

Nylon tubing is used to pipe refrigerant to the cooling unit which hardens wax between paper folds in a breadwrapping machine made by American Machine & Foundry Co., Brooklyn, N. Y.

An electronic programming system controls the number of copies produced by the new Ditto Inc. offset duplicator and sets the correct combination of ink and moisture.

Belt pull is isolated from the spindle of a vertical milling attachment by mounting the driven pulley on separate bearings. Unit is made by Hornamill Machine Tool Co. Ltd., London, England.

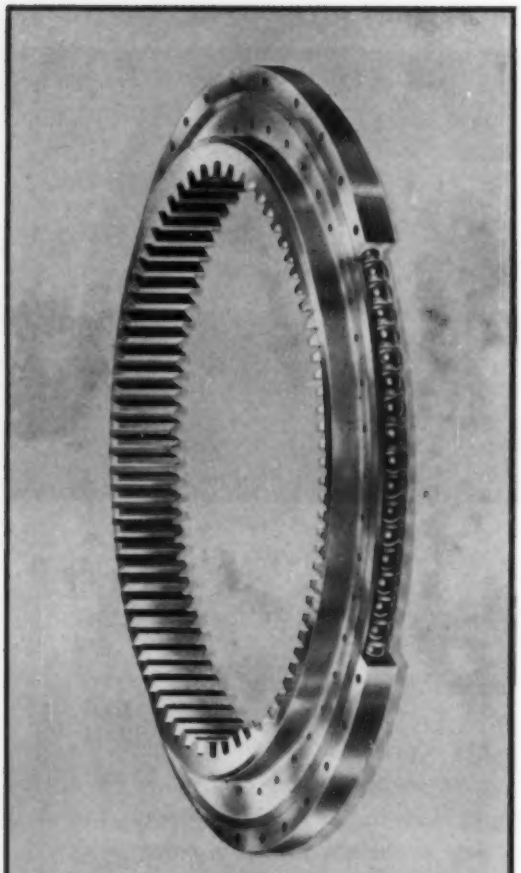
Ball Bearing screw jacks are used to apply a true axial load to the specimen in a creep tester made by Arcweld Manufacturing Co., Grove City, Pa.

A vertical spindle unit with an integral drive motor, built by Hornamill Machine Tool Co. Ltd., London, England as an attachment for horizontal milling machines, rotates 360 deg in the vertical plane and 90 deg in a second plane.

Three snap switches in the nose of a drill holder are series interlocks which shut off the power when the drill is not perpendicular to the workpiece. This self-aligning device is used on air-feed drills to countersink wing and fuselage skins by Martin Aircraft Corp., Baltimore, Md.

Parallelogram linkage, used to operate Caterpillar's new tractor-mounted rippers, reduces required hydraulic cylinder pressures by keeping the teeth at the same angle at all depths.

Transistorized military image-orthicon television camera made by RCA weighs only 31 lb and operates on less than 50 watts of power.



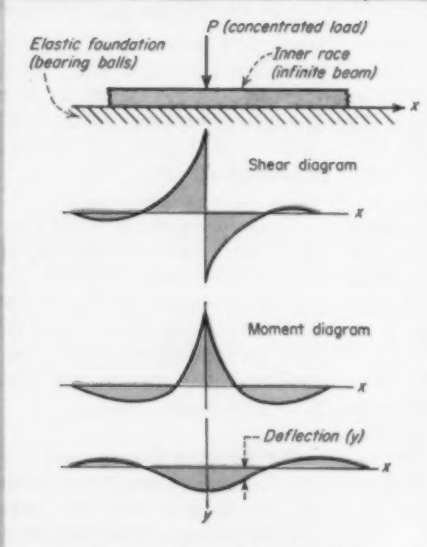


Fig. 1. Load, shear, bending moment and deflection of an infinite beam on an elastic foundation subjected to a concentrated load.

Inner races of large ring bearings experience concentrated loads from mounted structures. For analysis of forces, inner race is treated as an infinite beam resting on an elastic foundation. Formulas for stress problems, graphs and sample calculations are given for typical problem.

Stresses in Large

WHEN LARGE INTERNAL GEARS are mounted on ring bearings it is impractical to use a solid shaft to distribute the load uniformly to the rotating inner race. The outer race is generally well supported on its entire perimeter, but loads to the inner race are transmitted usually through several points around the race.

The uneven loading of a large-diameter bearing requires special analysis to make sure that the bearing will be able to carry the load. To determine the stresses and deflections in a ball bearing subjected to a concentrated load on its inner race various stress analyses must be combined. Stresses and deflections in an infinite beam resting on an elastic foundation are combined with the analysis of the forces acting on two contacting bodies.

Beam Stress and Deflection

If the inner bearing race is considered to be an infinite beam on an elastic foundation, Fig. 1, and subjected to a concentrated load

$$y_{max} = \frac{F}{2B}\sqrt[4]{\frac{B}{4EI}} \qquad (1)$$

$$M_{max} = \frac{F}{4}\sqrt[4]{\frac{4EI}{B}} \qquad (2)$$

$$P = \frac{F}{2}\sqrt[4]{\frac{Bl^4}{4EI}} \qquad (3)$$

If the balls in the race are close together their elastic reaction will be approximately continuous. The foundation modulus can then be considered as the reaction per unit length of foundation when the beam deflection is unity. The beam deflection at any point x is

$$y = \frac{FN}{2B}\,e^{-Nx}(\cos Nx + \sin Nx), \quad \text{where} \quad N = \sqrt[4]{\frac{B}{4EI}} \qquad (4)$$

The deflection of the beam takes the form of a wave of

THOMAS STONE WILLIAMS
Systems Specialist Electronics Division
American Machine & Foundry Company

Ring Bearings

diminishing amplitude.

$$a = 2\pi\sqrt[4]{\frac{4EI}{B}} \tag{5}$$

The bearing system must fulfill two conditions to conform to the treatment as an infinite beam; 1. the ball spacing must be small with respect to wavelength; 2. wavelength must be small compared to half the circumference of the inner race.

Ball Stress and Deflection

The elastic modulus of the beam foundation depends on ball diameter, spacing and composition as well as on the composition of the races and their respective curvatures. To determine the effective foundation modulus, the contact deflection of the ball and races measured as a function of ball load must be computed. To determine the safety of the design the average contact stress must be compared with the safe working stress of ball and race materials, and the closeness of ball and race contact area to the edge of the finished raceway must be computed.

Ball and Race Contact Deflection. For the general case of a ball in contact with two races, deflections at the points of contact between the ball and the races are:

$$e_1 = A_1\sqrt[3]{\frac{P^2}{K^2T_1}}; \qquad e_2 = A_2\sqrt[3]{\frac{P^2}{K^2T_2}} \tag{6}$$

The following formulas also apply:

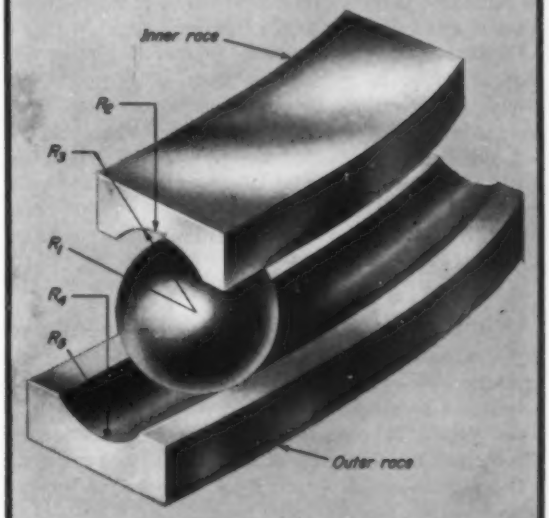
$$T_1 = \frac{4}{\frac{2}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}; \qquad T_2 = \frac{4}{\frac{2}{R_1} + \frac{1}{R_4} + \frac{1}{R_5}} \tag{7}$$

$$K = 8/3\,\frac{E_1E_2}{E_2(1 - v_1^2) + E_1(1 - v_2^2)} \tag{8}$$

$$V_1 = \text{arc cos}\left[\tfrac{1}{4}T_1\left(\frac{1}{R_2} - \frac{1}{R_3}\right)\right] \tag{9}$$

Symbols

- a = wavelength of race deflection function
- A_1, A_2 = functions of race curvature
- B = foundation elasticity modulus
- c = major semiaxis of elliptical contact area between ball and race
- d = minor semiaxis of contact area
- E = Young's modulus for race material
- e_1 = deflection at point of contact of ball and inner race
- e_2 = deflection at point of contact of ball and outer race
- $e = e_1 + e_2$
- F = load (lb.)
- I = moment of inertia for inner race (in.^{4})
- K = function of ball and race materials = 42,900,000 lb/in.^{2} for steel balls and races
- l = distance between balls (in.)
- M = bending moment
- $N = f(B, E)$
- P = ball load
- $R_1 \ldots R^5$ = radii (see diagram)
- S_c = contact stress between ball and race
- T_1, T_2 = functions of ball and race proportions
- V_1, V_2 = angles derived from arc cosine $[f(T_1R)]$
- v_1 = Poisson's ratio for ball material
- v_2 = Poisson's ratio for race material
- W, Z = functions of V and R_1/R_2
- x = distance from applied load at which deflection occurs
- y = beam deflection at x distance from load



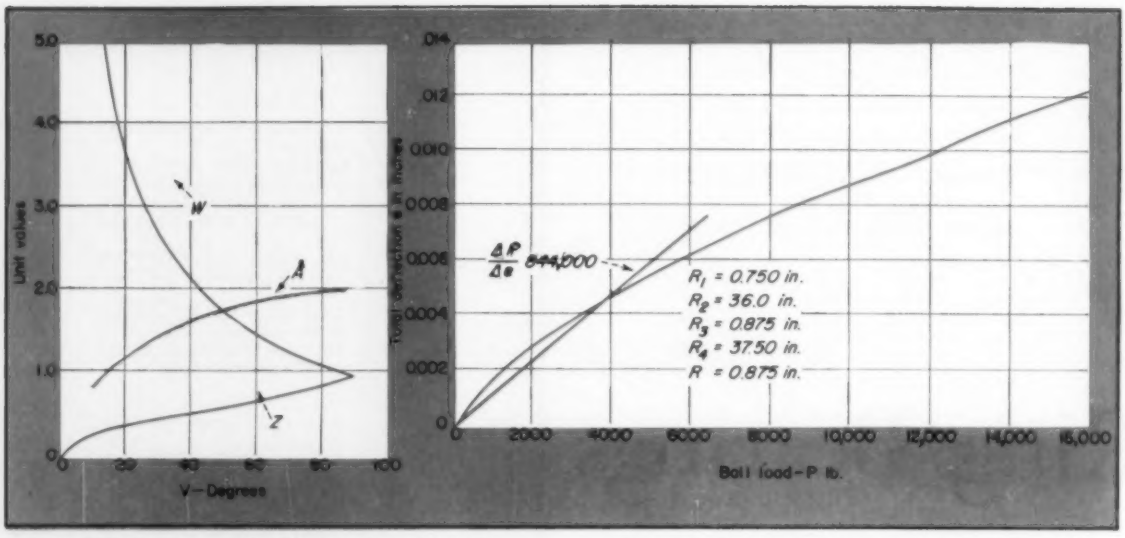


Fig. 2. Graph gives quick and ready means for finding *A, W* & *Z* for various values of *V*. These values are required in calculations for deflection and stress problems such as in typical example given.

Fig. 3. Total race deflection at point of contact with ball for typical bearing. Value of foundation elasticity modulus, *B*, is found from $\Delta P/\Delta e$ slope. Value is then used in equations for finding M_{max}.

$$V_2 = \text{arc cos}\left[\tfrac{1}{4}T_2\left(\frac{1}{R_3} - \frac{1}{R_4}\right)\right] \qquad (10)$$

It is convenient in preliminary computations to assume $1/R_2$ and $1/R_4$ are negligible.

Substituting values of A_1 and A_2 in equation (6) gives the values of the deflection between the ball and the races in term of ball load. Adding e_1 and e_2 gives the total contact deflection in terms of P

$$e_1 + e_2 = e \qquad (11)$$

To determine the foundation modulus B, compute several values of e and plot results as a function of P.

For bearing assembled without preload the spring constant $\Delta P/\Delta y$ to be used is the slope of a straight line through the origin, closely approximating the load deflection curve in the region below the maximum expected ball load. For bearings assembled with preload, the straight line should pass through a point corresponding to the value of the preload.

The elastic modulus of the foundation can be computed

$$B = \frac{1}{l}\frac{\Delta P}{\Delta y} \qquad (12)$$

Substituting B in equations (2) and (3) gives the expected maximum bending moment in the inner race and maximum ball load.

Average Contact Stress. The adequacy of the bearing is determined by comparing the average contact stress with the safe working stress of the ball and race materials.

The dimensions of the elliptical contact area between the ball and the race are found from:

$$c = W\sqrt[3]{\frac{PT}{K}} \qquad (13) \qquad\qquad d = Z\sqrt[3]{\frac{PT}{K}} \qquad (14)$$

Values for W and Z, both functions of V may be obtained from Fig. 2.

$$\max S_c = \frac{1.5P}{\pi cd} \qquad (15)$$

The limiting values for contact stress are usually stated as an average contact stress

$$\text{average } S_c = \frac{P}{\pi cd} \qquad (16)$$

Closeness of Contact Area to Raceway Edge. The second factor determining the adequacy of a bearing is the closeness of its contact area to the edge of the finished raceway. To determine this, the major semiaxis of the contact ellipse, equation (13), is compared with the corresponding dimension of the ball track. The contact area must not extend beyond the edge of the ball track.

EDITOR'S NOTE

Other articles on bearings which have appeared in *Product Engineering* are:

"Large Ball Bearings," October 1955 page 156, covers basic types in sizes of 6-in. bore and over; races and separators available; effect of speed and number and size of balls on capacity; selection of bearing material and tolerances.

"Integral Seal Ball Bearings," November 1955 page 179, tells how to select the combinations of bearing and seal for maximum life and performance.

"Answers to 17 Ball Bearing Problems," April 1955 page 195. Bearing specialists answer the questions.

"Chart for Determining Load and Life of Ball and Roller Bearings," *Product Design* annual for 1955 page E28, includes nomogram for finding load, speed and life in applications that fall between values for sets of conditions listed in manufacturers' catalogs.

"Scoring Characteristics of Bearing Metals," November 1954 page 171, gives results of a research of 38 elemental metals which were tested against steel.

"Split Ball Bearings and Where to Use Them," July 1954 page 197. Two types of split bearings are covered—the single fracture outer race, and double fracture both races.

Sample Calculations for Typical Problem

In a large bearing it is required to determine: 1. max. ball load; 2. max. contact stress between ball and races; 3. max. fiber stress for inner race. Other factors will be also evaluated during the calculations.

The following factors are known:

$$l = 3.5 \text{ in.}$$

$$F = 15{,}000 \text{ lb.}$$

$$I = 4 \text{ in.}^4$$

$$K = 42.9 \times 10^6$$

$$E = 30 \times 10^6$$

Ball and race material is steel;

From Equation (7)

$$T_1 = \frac{4}{\frac{2}{0.750} - \frac{1}{0.875} + \frac{1}{36}} = 2.572;$$

$$T_2 = \frac{4}{\frac{2}{0.750} - \frac{1}{0.875} - \frac{1}{37.5}} = 2.670$$

From Equations (9) and (10)

$$V_1 = \text{arc cos } \tfrac{1}{4}(2.572)\left[\frac{1}{-0.875} - \frac{1}{36}\right] = 41° - 20'$$

$$V_2 = \text{arc cos } \tfrac{1}{4}(2.670)\left[\frac{1}{-0.875} - \frac{1}{37.5}\right] = 41° - 54'$$

From Fig. 2

$$A_1 = 1.65 \qquad A_2 = 1.67$$

$$W_1 = 2.07 \qquad W_2 = 2.05$$

$$Z_1 = 0.58 \qquad Z_2 = 0.58$$

Substituting in Equation (6) gives

$$e_1 = 9.94 \times 10^{-6} P^{2/3}$$

$$e_2 = 9.32 \times 10^{-6} P^{2/3}$$

Adding e_1 and e_2 gives

$$e = 19.26 \times 10^{-6} P^{2/3}$$

Computing e for several values of P, and plotting gives the graph Fig. 3.

This function can be approximated by the line of slope $\Delta P/\Delta e = 844{,}000$ giving B a value (equation (12) of 241,000 lb/in^8. Substituting in equations (2) and (3) gives the maximum expected ball load and the maximum expected bending moment in the inner race.

$$P_{max} = \frac{15{,}000}{2}\sqrt[4]{\frac{241{,}000 \times 3.5^4}{4 \times 30 \times 10^6 \times 4}} = 3{,}930 \text{ lb.}$$

$$M_{max} = \frac{15{,}000}{4}\sqrt[4]{\frac{4 \times 30 \times 10^6 \times 4}{241{,}000}} = 25{,}150 \text{ in-lb.}$$

Assuming the bearing inner race is two inches deep, an extreme fiber stress of 6,300 psi would be expected.

To determine the dimensions of the elliptical contact area, substitute in equations (13) and (14)

For the inner race

$$c = 2.07\sqrt[3]{\frac{3{,}930 \times 2.572}{42.9 \times 10^6}} = 0.128 \text{ in.}$$

$$d = 0.58\sqrt[3]{\frac{3{,}930 \times 2.572}{42.9 \times 10^6}} = 0.0358 \text{ in.}$$

For equation (15) the average

$$S_c = \frac{3{,}930}{3.14 \times 0.128 \times 0.0358} = 272{,}500 \text{ psi}$$

For the outer race

$$c = 2.05\sqrt[3]{\frac{3{,}930 \times 2.670}{42.9 \times 10^6}} = 0.1281$$

$$d = 0.58\sqrt[3]{\frac{3{,}930 \times 2.670}{42.9 \times 10^6}} = 0.0362$$

$$\text{Average } S_c = \frac{3{,}930}{3.14 \times 0.1281 \times 0.0362} = 269{,}500 \text{ psi}$$

It is seen that the maximum loads expected allow satisfactory safety factors to be applied to the design.

FIBER-BASE STRUCTURAL MATERIALS...

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In structural materials derived from natural fibers, the basic raw material used is cellulose acetate, available in many forms such as wood pulp, cotton fabric and paper. When processed by chemical conversion, plastic impregnation or bonding with heat and pressure, these materials can be formed into sheets with good structural stability and high dielectric strength. Primarily laminates, some of these materials have been used in product design since 1870, and often provide economical alternatives to metals or pure plastics.

Seven fiber-base materials are compared in the accompanying chart which shows physical and mechanical properties, resistance to chemical environment, finishes, colors and forms available, and comparative average costs. One of the seven, glass fiber-reinforced polyester laminate, is not derived from natural fiber; however the fact that it is widely used for structural purposes and is fiber-based, makes it of interest in this comparison.

VULCANIZED FIBRE is not vulcanized in the usual rubber curing sense; it is rather a product of chemical hardening or gelling. It is made by combining layers of chemically gelled paper, using either wood pulp or rag as a base; a rag base gives higher mechanical strength. The chemical compound used in gelling the paper is removed by leaching. The resulting product, after drying and calendering, is a dense partially regenerated cellulose in which the fibrous structure is retained in varying degrees, depending on fiber grade. Three basic grades are:

Electrical insulation grade fibre is used for electrical and other applications requiring difficult bending or forming as shown in Fig. 1. If the shape is simple it can be formed dry on a punch press. For larger and more complex shapes, fibre sheet is moistened and formed in hot dies to reduce drying time. Feasible forming processes include: bending, corrugating, drawing, swaging, cupping, deep-cupping, flaring, spinning and embossing.

Commercial grade fibre is a general purpose grade used for volume parts fabricated primarily by punching. Parts shown in Fig. 2 were swage-formed in a single punch press operation. Commercial grade in sheet form runs up to 2 in. thick.

Bone grade is a higher density vulcanized fibre with greater hardness and stiffness. It machines easily with less tendency to de-laminate than the other grades, conse-

PROPERTY	VULCANIZED FIBRE			PHENOLIC LAMINATES		FIBRE BOARD	RAG INSULATION	POLYESTER LAMINATE	WOOD FIBRE BOARD	WALL BOARD
	Electrical Insulation grade	Commercial grade	Bone grade	Paper Base Phenolic (P)	Cotton Fabric Phenolic (C)	Latex Binder Wet Machine Board, Calendered	Cylinder Machine Rag Base, Glazed	Fiberglass reinforced	Wood Base, Multiple Ply	Cellulose Base, Multiple Ply
Specific Gravity	0.90–1.40 depending on grade, thickness and finish			1.33	1.35	0.95–1.20	1.30–1.44	1.70–1.80	1.02	0.55
Specific Volume, *cu in./lb*	19.8–30.8 depending on grade, thickness and finish			20.8	20.5	29.2–23.1	21.3–19.2	16.0	27.1	50.1
Tensile Strength, *psi*	8000/6000[1]	7500/5500	8000/6000	10000/9000	11200/9500	3000/1700	17000/4500	4000–10000	3100	2000/1000
Elongation, *per cent*	5.0/21.0	5.0/13.0	N.A.[2]	0.0/0.0	0.0/0.0	11.0/23.0	7.0/18.0	N.A.	N.A.	N.A.
Tensile Modulus, *psix10⁶*	N.A.	N.A.	1.2/0.8	N.A.	N.A.	N.A.	N.A.	1.6–2.0	N.A.	N.A.
Flexure Modulus, *psix10⁶*	N.A.	N.A.	1.0/0.7	1.2/0.9	1.0/0.9	N.A.	N.A.	N.A.	N.A.	N.A.
Flexure Strength, *psi*	N.A.	14000/12000	15000/13000	15000/13000	22000/18000	N.A.	N.A.	5000–25000	N.A.	125/70
Compressive Strength, *psi*	N.A.	20000	30000	25000	37000	N.A.	N.A.	N.A.	N.A.	N.A.
Impact Strength, *ft-lb/in.*	N.A.	1.0–3.5 depending on grade and direction		0.8/0.6	2.3/2.2	N.A.	N.A.	3–6	N.A.	N.A.

Hardness, *Rockwell*	N.A.	50R	80R	90M	103M	N.A.	N.A.	95M	N.A.	N.A.
Thermal Conductivity *Btu/hr/sq ft/F per ft*	0.168	0.168	0.168	0.169	0.169	N.A.	N.A.	N.A.	0.116	0.036
Specific Heat, *Btu/lb/F*	0.403	0.403	0.403	0.35–0.40	0.35–0.40	N.A.	N.A.	N.A.	N.A.	N.A.
Expansion Coefficient, *per deg C*	$2\times10^{-5}/3\times10^{-5}$	$2\times10^{-5}/3\times10^{-5}$	$2\times10^{-5}/3\times10^{-5}$	$7.7\text{x}10^{-6}/12\text{x}10^{-6}$	$10\text{x}10^{-6}/12\text{x}10^{-6}$	N.A.	N.A.	N.A.	N.A.	N.A.
Max. Heat Resistance	AIEE Class A	Continuous operation, 200 F		Cont. oper. 250 F	Cont. oper. 275 F	Cont. oper. 200 F	AIEE Class A	Cont. oper. 250 F	Cont. oper. 200 F	Cont. oper. 200 F
Resistance to: Humidity	Moisture content stabilizes with relative humidity			Good	Fair	Fair	Poor	Excellent	Fair	Fair
Water immersion	Absorbs water, swells, does not delaminate			Low absorption, does not swell or delaminate	Medium absorption, does not swell or delaminate	Absorbs water, swells, will delaminate	Absorbs water, swells, will delaminate	Low absorption, does not delaminate	Absorbs water, swells	Absorbs water, will delaminate
Dilute acids	Equivalent to cellulose in other forms			Good	Good	As cellulose	As cellulose	Good	Poor	Poor
Dilute alkalis				N.R.[2]	N.R.			N.R.	Poor	Poor
Organic Solvents	Equivalent to cellulose in other forms			Good	Good	As for latex binder	Absorption high, resistance good	Good	Poor	Absorption high, resistance good
Oils & Greases	Good. No wicking action			Good	Good	Absorption fair, some wicking	Absorption high, will wick	Good	Absorption fair, some wicking	Absorption high, some wicking
Fungus	Fungus resistant grades available			Fair	Fair	Fair	Poor	Good	Poor	Good
Forming Qualities	Excellent	Fair	Good	N.R.	N.R.	Good	Excellent	N.R.	Poor	Poor
Machining	N.A.	Excellent with standard wood or metal working tools		Good	Good	N.R.	N.R.	Fair	Fair	Fair
Finishes	Lacquers, enamels, varnish, wax and vinyl; by brush or roll coat			Limited	Limited	Limited	Absorbent	Limited	Paint, lacquer, enamel	Paint, laquer, enamel
Arc Resistance, *sec*	Excellent, non-tracking. 150–180			N.R.	N.R.	N.A.	N.A.	135	N.R.	N.R.
Dielectric Strength *volts/mil*	175–300	50–175	50–175	650	N.R.	100–250	300	400–500	N.R.	N.R.
Min.BurstingStrength, *per 0.001 in.thickness*	0.005–0.020 in. 15 psi	N.A.	N.A.	N.A.	N.A.	0.032 in. 10 psi	0.007–0.020 in. 18–20 psi	N.A.	6 psi	15–17 psi
Colors	Gray or blue-gray	Red, black, gray white	Gray or tan	Black, natural, chocolate	Natural, black	Gray, red, black, brown	Gray, tan	Unlimited	Brown	Cream
Available in:	Sheets, rolls, strips, fabricated parts	Per col. 1 up to 0.090 in.; sheets over 0.090 in.	Sheets & strips	Sheets, strips & fabricated parts	Sheets, strips & fabricated parts	Sheets, rolls & fabricated parts	Sheets, rolls & fabricated parts	Sheets, strips & molded parts	Sheets	Sheets and strips
Standard Thickness Range, *in.*	0.004–1/8	0.005–2	1/32–1/2	0.010–1/4	1/32–10	1/32–1/8	0.007–1/32	1/32–1 1/8	1/16–5/16	1/8–3/8
Base Price: standard grades, *dollars/lb*	0.42	0.36–2.04	0.36–0.43	0.80	1.34	0.35–0.65	0.45–0.75	0.94–3.30	0.13	0.12

Footnotes: [1] Machine direction/cross direction [2] Not available [3] Not recommended

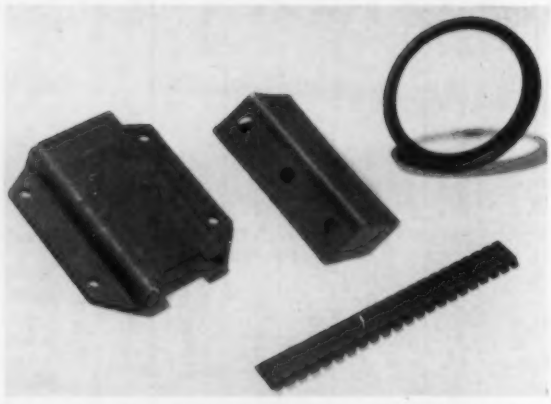

Fig. 1—Formed parts of electrical grade vulcanized fibre. Left to right: electric lock insulator, terminal insulator for fph motor, insulator ring for auto horn, and TV picture tube insulator.

quently is often used to fabricate threaded parts. Commercial and Bone grade materials can be polished to high finish. The electrical parts shown in Fig. 3 are good examples of the complex machining operations possible with this material.

PHENOLIC LAMINATES are fibrous sheet materials impregnated with thermosetting phenolic resin binder and consolidated under high temperature and pressure into hard solids of high mechanical strength. Fibrous sheet materials used include: cellulose paper, asbestos paper, cotton fabric or mat, asbestos fabric or mat, wood veneer, nylon and glass fabric. While properties can be varied widely by choice of base material, binder and processing, two basic grades are useful in most applications:

Paper base phenolic is primarily intended for hot punching. With good punching practice, sheets as thick as $\frac{1}{4}$ in. may be punched cold; heated to 120-140 C, punchings of $\frac{1}{8}$ in. stock are feasible. Tubing is readily made by wrapping and impregnating paper or other base material over a mandrel to the desired thickness.

Cotton fabric phenolic uses 4-oz cotton canvas as base material, providing a strong tough laminate suitable for gears and other applications requiring high impact strength. Heavier fabrics result in higher impact resistance, but rougher machined edges. This grade does not have controlled electrical properties and its use in electrical applications is not recommended.

LATEX-BONDED FIBRE BOARD is a cellulose base cylinder-machined board saturated with latex for laminating purposes. Impregnating with latex provides ductility for deep drawing applications such as toe boxes in the shoe industry. Latex impregnation also provides good moisture resistance. Thicknesses up to $\frac{1}{8}$ in. are available in this essentially low strength material.

RAG INSULATION PAPER is a cylinder machined product, usually glazed, with excellent dielectric strength for electrical insulation applications. Multiple wet plies are rolled together and dried, with subsequent calendering to form a dense, tough laminate. Wet-forming properties are excellent, allowing deep-cupped parts to be made.

POLYESTER LAMINATES can be made with either glass fiber mat or glass fiber cloth as a base. Fiber mat has the advantage of not folding over sharp corners. Impregnated with liquid monomer containing inorganic fillers and catalyst, glass mat is molded into parts of exceptional hardness and chemical and electrical resistance.

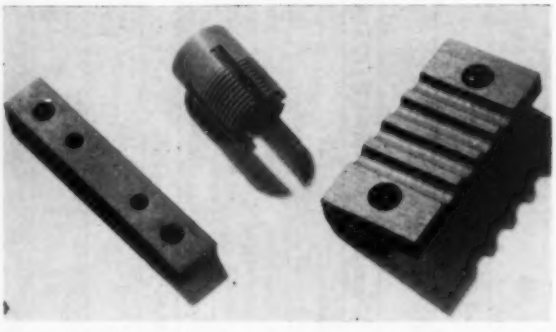

Fig. 3—Machined parts of bone grade vulcanized fibre. Left to right: terminal strip, slotted and threaded sleeve for electrical cable coupling, and spacer cleat for lead-in wires to fhp motors (other half not shown). This grade has non-carbonizing characteristics under surge currents of 100,000 amp.

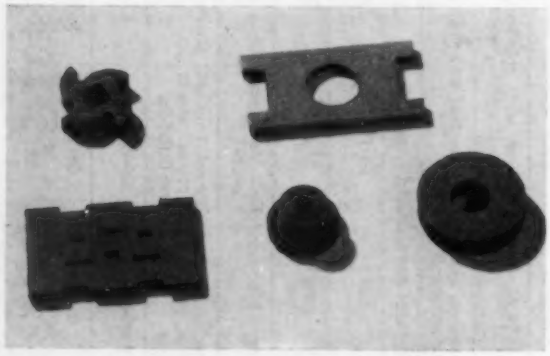

Fig. 2—Punched-formed parts of commercial grade vulcanized fibre. Top: star-wheel for pull chain electric light socket (two teeth carry metal contacts, two remain bare), magnetic core spacer. Bottom: switch insulator (note phenolic plastic core for good electrical strength in moist atmosphere), flanged washer for auto generator, and spigot washer.

WOOD FIBRE BOARD, commonly called "hardboard", is a heat and pressure-laminated product of closely packed and bonded wood fibres. Material is characterized by smooth, scratch-resistant surface. Dense bonded fibre structure precludes extensive forming. Using moisture and heated dies, however, a 2 in. radius is possible with $\frac{1}{8}$ in. thick sheet; formed cold and dry, 10 in. is the minimum radius. Material is splinter and sliver-free, a safety factor in formed panels for bus interiors. Punched and die cut parts are feasible such as back panels of radios and television sets. Wood fibre board may be laminated up to 2 in. thick for backing punching dies.

WALL BOARD, a laminated wastepaper-base product, has the lowest mechanical strength of the fibre-base structural products. With a low thermal conductivity, it finds considerable use as thermal insulation in both the architectural and container fields. It is available in large sheet sizes and has fair sound-absorbing characteristics.

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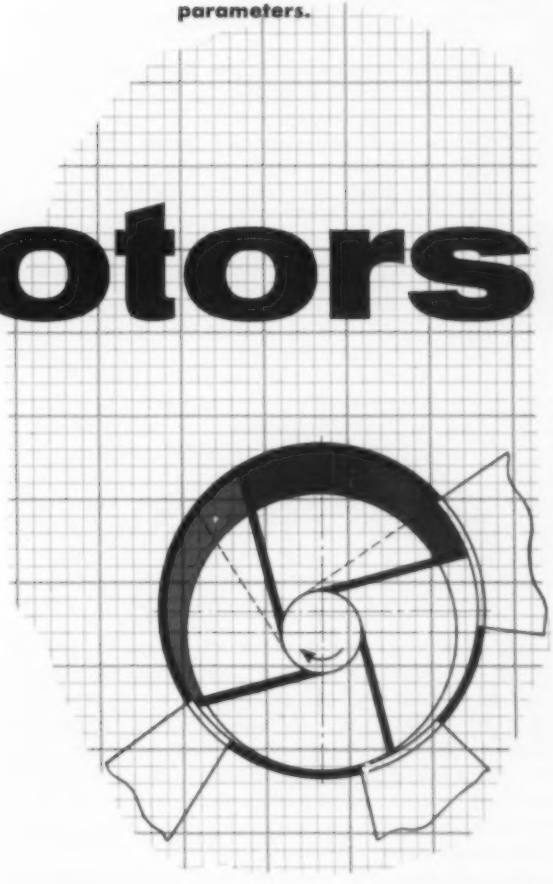
A comprehensive study of flow through vane air motors in which pressure drops, torque losses and compression and expansion efficiencies are derived in explicit form. These relationships are then made non-dimensional and plotted in two graphs to permit easy design analysis of new and existing motors and a quick determination of the effect of changing the various motor parameters.

analysis and design of

air motors



OTMAR E. TEICHMANN
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air motors

symbols

A — Area, in^2.
A_H — Equivalent flow area of lead-in passages, in^2.
A_L — Leakage flow area, in^2.
b — Vane breadth, in.
b' — Projected vane breadth, in.
C — Design constant determined by location of inlet and outlet orifices and number of vanes.
C_1 — A_m/eL
C_2 — Ratio of mean pressure drop to inlet pressure drop.
C_3 — Ratio of mean torque radius to housing radius.
d — $(k-1)/k$
e — Eccentricity of rotor in housing, in.
E_{mech} — Mechanical efficiency.
G — Total weight rate of air flow to motor, lb/min.
G_L — Leakage weight rate of air flow, lb/min.
G_{th} — Theoretical air consumption, lb/min.
g — Acceleration of gravity, ft/sec^2.
h — Oil film thickness, in.
hp — Horsepower.
k — Adiabatic expansion coefficient.
K — Supply air factor, min/in.
n — Polytropic expansion exponent.
N — Rotor speed, rpm.
N_s — Rotor speed, rps.
p_o — Pressure of ambient air (atmospheric), psi.
p_1 — Pressure of air in reservoir, psi.
p_a — Pressure at inlet to space between vanes, psi.
p_b — Pressure of air trapped between vanes after expansion, psi.
p_m — Average pressure to do equivalent work of expansion cycle, psi.
Q — Total air consumption, cfm.
Q_L — Leakage flow, cfm.
Q_{th} — Theoretical air consumption, cfm.
r — Rotor radius, in.
R — Housing radius, in.
R_g — Gas constant.
R_t — Torque radius, in.
S — Motor size factor, in.^{3}.
t — Vane thickness, in.
T — T_{in}/Sp_o
T_f — Friction torque, ft-lb.
T_{in} — Input torque, ft-lb.
T_{out} — Output torque, ft-lb.
T_v — Viscous friction torque, ft-lb.
U — Vane velocity, in/sec.
v_a — Specific volume of air at intake port, ft^3/lb.
V_o — Volume of air at atmospheric pressure, ft^3.
V_1 — Volume of air after compression, ft^3.
V_a — Volume of pressurized air trapped between vanes at instant inlet port is closed, in^3.
V_b — Volume of air between vanes just prior to opening of exhaust port, in^3.
W — Compression or expansion work.
z — Number of vanes.
α — Non-dimensional area, A/R^2.
ϵ — Non-dimensional eccentricity, e/R.
μ — Dynamic viscosity, slug/ft-sec.
ξ — Non-dimensional pressure ratio, m/r.
ξ_{cr} — Critical pressure ratio.
ρ — Air density, lb/ft^3.
τ — Viscous sheer stress, psi.
Φ — Leakage — inlet ratio, in.
Ψ_L — Leakage flow variable.
Ψ_{max} — Non-dimensional flow variable.
Ω — Motor-inlet ratio, in.

BASIC ADVANTAGES in the use of air motors for portable power are: low weight per horsepower, small size, indifference to overload and stall, cool operation, the availability of speed control, and indifference to dirty or explosive atmospheres. Disadvantages as compared to electric power are: lower efficiency, higher first cost (nearly double the equivalent electric motor) and a maintenance cost which will be approximately the same and perhaps more expensive than electric motor maintenance.

Poor efficiency is the result of the need to charge the air motor for the cost of compressing air to operating pressure as well as the inefficiencies in expanding it during the work cycle. In this article efficiency of air compression and expansion in vane motors will be analyzed and design principles derived that may be used as a basis of synthesizing new designs and predicting their performance.

Power for Air Compression

Actual air compression follows a polytropic curve as shown in Fig. 1. Work required for this compression is given by the equation

$$W = \frac{n}{n-1} p_o V_o \left[1 - \left(\frac{p_1}{p_o}\right)^{\frac{n-1}{n}}\right] \qquad (1)$$

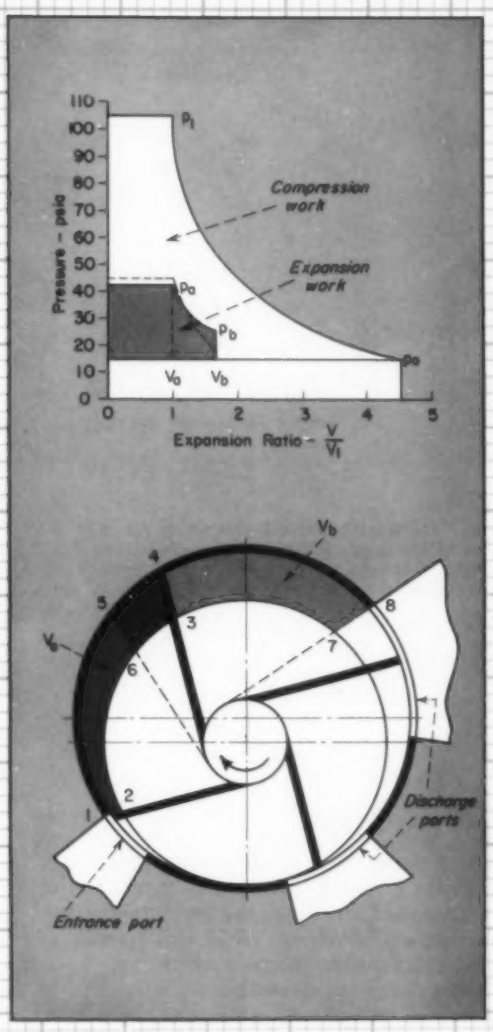


Fig. 1 — Absolute pressure versus expansion ratio for compressor (in color) and air motor (shaded). Note that for this instance the motor is only approximately 25 per cent efficient.

Fig. 2 — Schematic cross-section of air motor. Intake air fills space 1234 at which time entrance port is closed off. This air expands to volume 5678 when discharge port is opened.

If the compression were isothermal less work would be needed and this difference increases with increasing pressure ratio p_1/p_o. Therefore when pressure ratios are higher than 7, compression is carried out in two or more stages with intercoolers between stages to more nearly approximate isothermal conditions. Table I lists the theoretical horsepower requirement for compression of 100 cfm of free air (p_o = 14.7 psia) to 90 psig for isothermal, adiabatic and polytropic conditions. Actual brake horsepower as estimated by the Compressed Air Handbook is approximately 18.0 hp/100 cfm for these conditions.

Power from Compressed Air

If the sequence of operations in a compressor is reversed and the valves properly governed a compressor can be operated as an air motor. The formulas given in Table I are still valid for idealized conditions. Actual air motors are far from ideal as shown in Fig. 1. In this graph the abscissa is plotted as an expansion ratio with the compressed volume assume as unity. To achieve a compression of 7.12 (104.7/14.7) the compressor volumetric change must have been 4.52 for a polytropic compression in which $n = 1.3$.

Compressed air is then piped to the motor. If the motor could receive the air without pressure loss and expansion of 4.52 times were possible within the motor then the motor diagram would be nearly the same size as the compressor diagram, indicating high efficiency. Unfortunately practical limitations in design prohibit this and a typical vane motor is designed with an expanson ratio of only 1.67. Compressed air reaches the entrance port at only 42 psia and the darkened area represents an effective use of the compressed air with an efficiency of only 25 per cent.

This low efficiency may be improved by reducing pressure drop between supply reservoir and entrance port of motor. Further improvement is possible by increasing the expansion ratio in the motor.

Vane Motor Torque

A diagrammatic sketch of a vane motor is shown in Fig. 2. A cylindrical rotor with sliding vanes is set eccentrically in a cylindrical housing. Compressed air is admitted through the inlet ports and fills the cavity between vanes, housing and rotor. Pressure unbalance acting on the vanes causes the rotor to turn. Torque, T, developed at the shaft is proportional to the product of effective vane area, A, pressure unbalance, Δp, and torque radius, R_t, measured from the center of pressure to center of rotor shaft.

$$T = \Delta p A R_t \qquad (2)$$

Effective vane area is the projection of the actual vane area on the radial plane. If axial vane length is L, and actual and projected vane breadth b', and b respectively, instantaneous torque is the product

$$T = \Delta p b L R_t \qquad (3)$$

Volumetric Expansion in Vane Motors

Neglecting leakage, the space between two consecutive vanes is filled with high pressure air when the space is open to the entrance port. Filling stops when the trailing vane

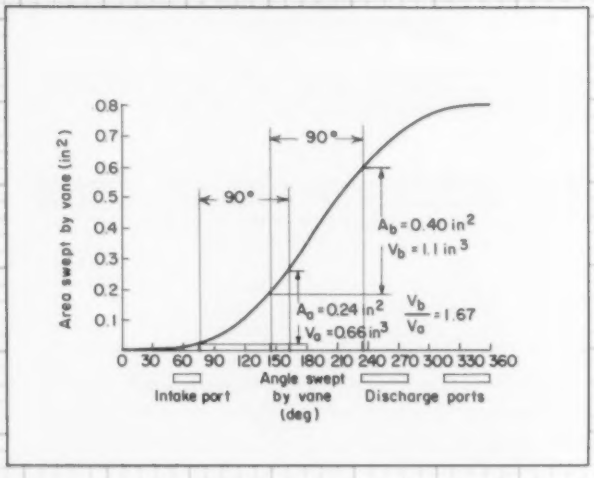


Fig. 3 — Area swept by vane plotted versus angular position of vane. Locations of intake and discharge ports permit reading initial and final volumes and the computation of expansion ratio.

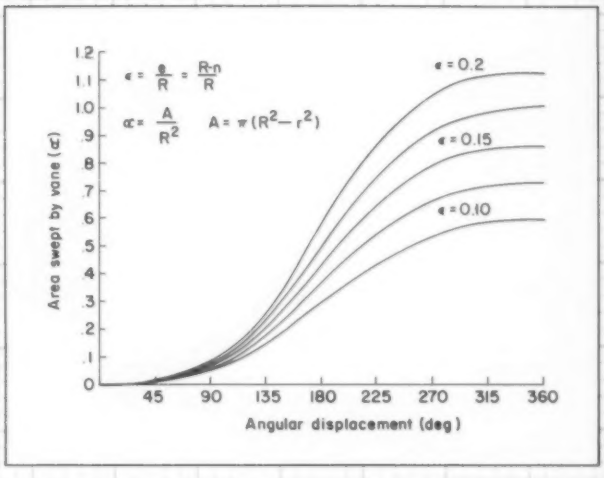


Fig. 4 — Non-dimensional plot of swept area versus vane angle. Having chosen radius of housing and eccentricity, area versus angle may be determined for any motor.

covers the port and the volume of air, V_a, trapped between the two blades expands as the rotor turns eccentrically. Just before the leading vane opens to the exhaust port maximum expansion has taken place to volume V_b. Expansion ratio V_b/V_a is determined by the motor dimensions, the location of entrance and discharge ports and the number of vanes.

A graph of accumulated area swept by the vanes of a typical grinder motor is shown in Fig. 3. Area is plotted as a function of angular position of vane and the locations of intake and discharge ports are indicated. Cross sectional area enclosed between two vanes 90 deg displaced is determined by reading the difference in areas on the ordinate between any two points 90 deg apart on the abscissa. Since swept area is proportional to volume, the volumetrical expansion ratio may be quickly determined from this plot.

An ideal air motor would expand the compressed air to atmospheric pressure within the motor. Physical size limitations in eccentricity and number of vanes restricts the compression ratio severely.

Derivation of curves like that of Fig. 3 requires laborious computation or careful graphical layout. A convenient non-dimensional set of curves has been developed as shown in Fig. 4 which will handle all sizes of vane motors of varying eccentricity. In this plot non-dimensional eccentricity, ϵ, is

$$\epsilon = \frac{e}{R} = \frac{R-r}{R} \tag{4}$$

and non-dimensional area, α, is

$$\alpha = \frac{A}{R^2} \tag{5}$$

Power Output

Instantaneous torque developed by a vane was derived in Eq. (3) above. Projected vane breadth, b, and torque radius R_t, change much less during the working cycle than does the pressure and so average values may be used as scaled off a cross-sectional drawing of a motor.

Pressure follows a polytropic expansion

$$p_b = p_a \left(\frac{V_a}{V_b}\right)^n \tag{6}$$

This pressure may be plotted as shown in Fig. 5 in which the space between adjacent vanes is filled at a constant pressure p_a to volume V_a. It then expands to p_b, exhausts at atmospheric pressure, p_o, and then the volume of air remaining is evacuated in preparation for refill at p_a. Superimposed on this graph is a rectangle (6745) equal in area to the expansion curve (12345). Average pressure, p_m, that will produce the same work over the cycle may be calculated by the following equation.

$$\frac{p_m}{p_a} = \frac{V_a}{V_b}\left\{1 + \frac{1}{n-1}\left[1 - \left(\frac{V_b}{V_a}\right)^{1-n}\right]\right\} \tag{7}$$

$$\Delta p_m = p_m - p_o \tag{8}$$

This equation has been solved for several expansion ratios and for values of $n = 1.4$ and 1.3 in Table II.

When substituted in Eq. (3) the values of Δp_m, b, L, and R_t will solve for an average torque per vane over a full

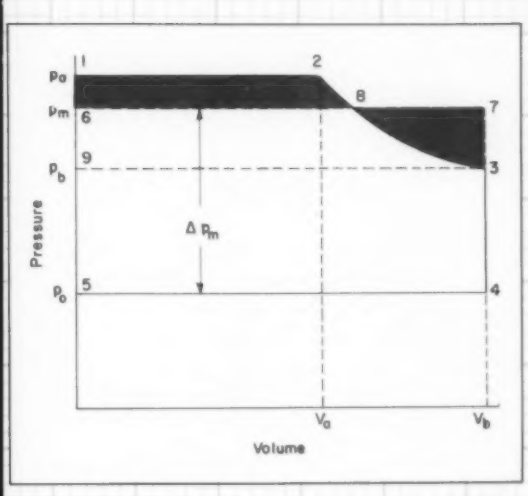


Fig. 5 – Pressure-volume plot of air expansion in motor. Curve 12345 may be approximated by an equivalent area 4567 making the computation much simpler.

TABLE I – Compression Work

	Formula	Theoretical hp/100cfm
Isothermal	$W = p_o V_o \ln \left(\frac{p_o}{p_i}\right)$	12.6
Adiabatic	$W = \frac{k}{k-1} p_o V_o \left[1 - \left(\frac{p_i}{p_o}\right)^{\frac{k-1}{k}}\right]$	17.0
Polytropic	$W = \frac{n}{n-1} p_o V_o \left[1 - \left(\frac{p_i}{p_o}\right)^{\frac{n-1}{n}}\right]$	15.9

Table II – p_m/p_a for Typical Expansion Ratios

V_b/V_a	n	p_m/p_a
1.50	1.4	0.917
1.67	1.4	0.877
2.00	1.4	0.803
1.50	1.3	0.919
1.67	1.3	0.882
2.00	1.3	0.812

revolution. When multiplied by the number of vanes z, the speed, N, and a conversion constant, horsepower output appears in the familiar form

$$hp = \frac{TzN}{63{,}000} \tag{9}$$

Leakage

Weight rate of air consumed by a motor without leakage will be called theoretical weight rate of air consumption G_{th}.

$$G_{th} = \rho_a \frac{V_a}{1728} zN \tag{10}$$

where ρ_a is the density of air (lb/ft³) trapped in volume V_a (in³). N is speed (rpm) and z the number of vanes. When expressed in terms of cfm of free air

$$Q_{th} = \frac{G_{th}}{\rho_o} \ (cfm\ free\ air) \tag{11}$$

where ρ_o is the weight density of atmospheric air (ρ_o = 0.076 lb/cu ft).

To determine ρ_a, pressure p_a must be known. From the p–V diagram of the motor Fig. 5, if the power developed by the motor is known, the area (12345) may be calculated by

$$\Delta p_m V_b = \frac{396{,}000 \times hp}{E_{mech}\, zN} \ (in\text{-}lb) \tag{12}$$

where E_{mech} = mechanical efficiency.

Since V_a and V_b are known Δp_m and p_m ($= \Delta p_m + p_o$) can be determined and p_a may be established by referring to Table II.

$$\rho_a = \rho_i \left(\frac{p_i}{p_a}\right)^{\frac{1}{n}} \tag{13}$$

where ρ_i and p_i are reservoir density and pressure. Thus Q_{th} is evaluated and compared with total air consumption, Q, of the motor.

Leakage

Difference between the actual and the theoretical air consumption is leakage flow.

$$Q_L = Q - Q_{th} \tag{14}$$

Leakage flow occurs mainly at the edge of the vanes and at the end plates. Vane edge leakage occurs only during the time when the air inlet port and the discharge port are straddled by two consecutive vanes. End plate leakage from entrance to discharge ports of the motor is constant and of a larger magnitude than vane edge leakage. For the purpose of this analysis, vane edge leakage will be lumped with end plate leakage.

In addition to Q_L there is a second kind of leakage which takes place after the air has been trapped between the motor vanes. This leakage does not affect Q_L but causes a change in pressure on the vanes. Flow from a trapped volume around a vane to the exhaust port decreases the mean torque acting on the vanes and in order to correct for the

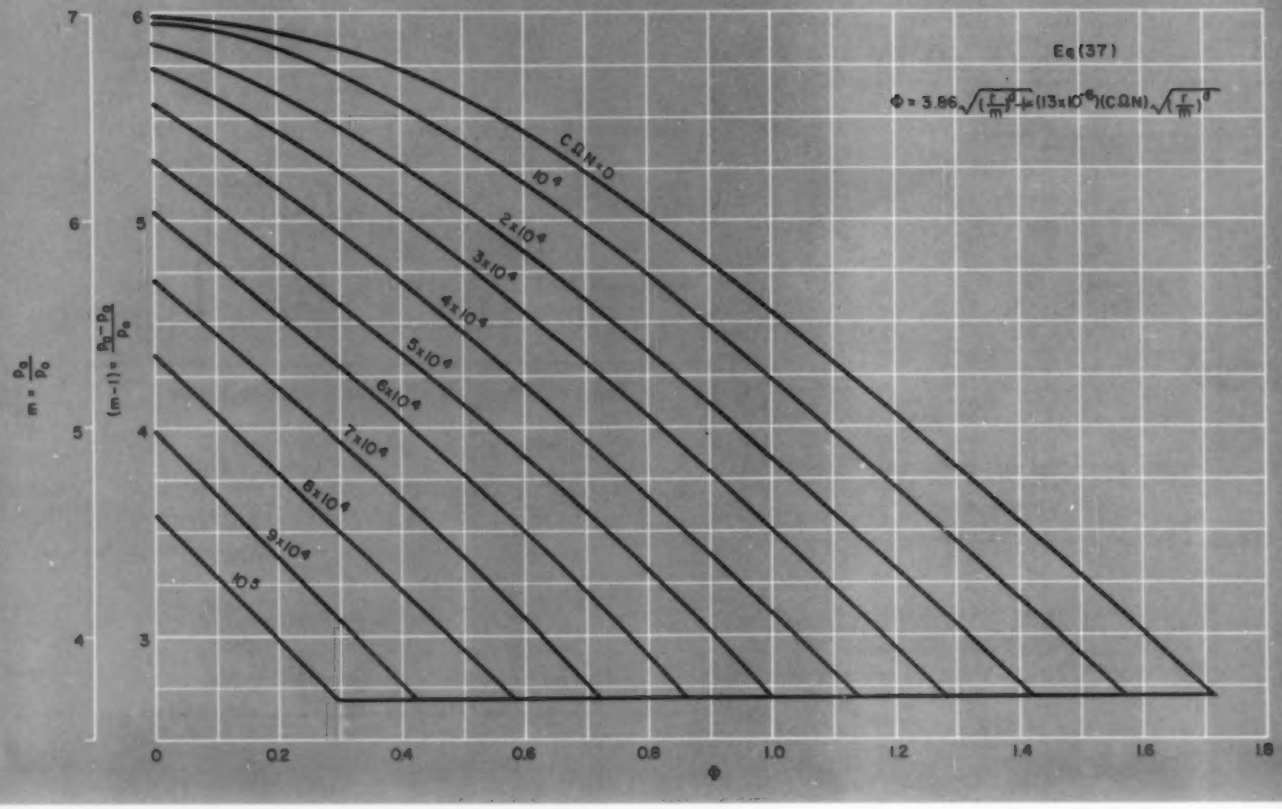


Fig. 6 — Variation of $m(=p_a/p_o)$ with $\phi(=A_L/A_H)$ with $C\Omega N$ as the parameter. Reservoir temperature is assumed at 100 F.

corresponding decrease in area of the $p - V$ diagram, a higher p_a is needed as shown in dotted outline of Fig. 1. Area lost due to lowered p_b has to be compensated for by a higher p_a. In this analysis no special correction will be made for this leakage because its effect is similar in nature to the change from adiabatic to polytropic conditions and can be taken care of by a proper choice of the exponent n.

Torque

Torque input exerted by compressed air on the vanes of the motor is used to overcome external torque load and internal friction torque losses.

$$T_{in} = T_{ext} + T_F \tag{15}$$

There are two main sources of torque losses: bearing friction and vane friction. Bearing friction is low for a motor without speed reduction gears and somewhat larger with them. Experimental data indicate that over-all torque losses are linear with speed for low speeds and increase more rapidly at higher speeds. Assuming a thin film of oil between end face of vane and motor housing, viscous shear may be estimated and compared with experimentally determined data.

Viscous shear stress, τ in the oil film between end face of vane and housing is

$$\tau = \mu \frac{U}{h} = \mu \frac{2R\pi N_s}{h} \tag{16}$$

where h is the oil film thickness, U the vane velocity, N_s the speed of rotor in rps and R the housing radius used as a mean torque arm for all vanes.

$$T_v = \tau\, t\, L\, Rz \tag{17}$$

$$T_v = \mu \frac{2R^2\pi N_s\, t\, L\, z}{h} \tag{18}$$

where t is the vane face thickness. As a sample illustration a typical grinder motor has the following dimensions

R = 1 in.
L = 2.75 in.
z = 4 vanes
t = 0.096 in.
N_s = 90 rps
h = 0.0003 in.
μ = 5×10^{-4} slug/ft-sec

The oil is assumed to be a light grade (SAE 10) type and the film thickness is an assumed value. Applying these quantities to Eq. (18) and changing inches to feet

$$T_v = 5 \times 10^{-4} \frac{2(1)^2\,\pi\,(90)\,(0.096)\,(2.75)\,(4)}{0.0003 \times 12^2}$$

$$T_v = 0.575\ ft\text{-}lb$$

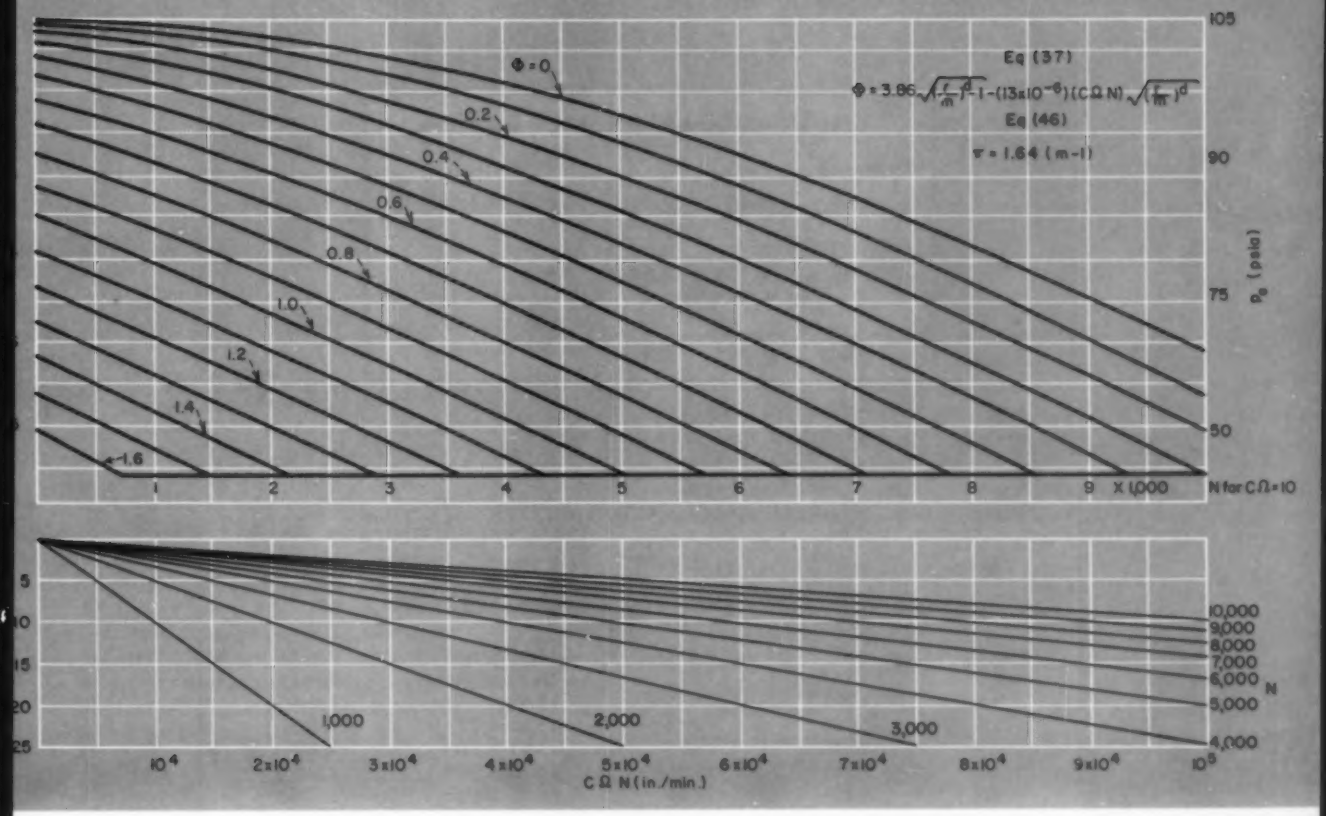


Fig. 7 — Variation of $p_a (= mp_o)$ and T $(= T_{th}/eKLp_o)$ with $C\Omega N$ as the parameter. Reservoir temperature is assumed at 100 F. $C\Omega N$ scale at bottom is equipped with N values for various values of $C\Omega$.

Written in more convenient terms viscous friction torque appears as

$$T_v = \frac{\mu \pi z}{20{,}736} \times \frac{D^2 t L}{h} \times N \ (ft\text{-}lb) \qquad (19)$$

where all dimensions are in inches, speed in rpm and dynamic viscosity in slug/ft-sec.

Viscous friction torque is here assumed to be proportional to speed. Experimental data on some motors support this assumption. On others in which a more rapid increase of friction torque is noted at higher speeds it may be assumed that film thickness, h, decreases as centrifugal force increases.

DESIGN ANALYSIS

A design theory has been derived which will enable the design engineer to predict the performance of a new unit on the basis of the chosen design dimensions without having to depend on past experience. It is intended to give a method of systematizing performance data of existing designs and to show how to apply them to new ones in a rational manner. A number of simplifying assumptions have been made to make the analytical treatment possible. However, as long as theory is checked against experimentation on available units, the simplifications will not limit the validity of the analysis for practical engineering applications.

Assumptions

Basic objective of this analysis is to establish analytical relationships between the performance characteristics (torque-speed curve and discharge-speed curve) and the basic design dimensions of the vane-type air motor (diameter of the motor housing $2R$, eccentricity e and axial length L).

The following concepts were used for the analysis:

1) Pressure drop in the lead-in passage to the inlet port of the motor unit $(p_i - p_a)$, is a function of total flow or total weight rate of discharge.

2) After passing through the lead-in passage, total flow splits into two parts: flow through the motor Q_{th}, and leakage flow Q_L.

3) Flow through the motor, Q_{th}, is determined by motor dimensions (e, R, L), motor design (number of vanes z, locations of air inlet and outlet), air density at entering the motor ρ_a, and speed of the motor N.

4) Leakage flow Q_L is determined by the leakage flow area A_L and pressure p_a. Area A_L is proportional to clearances, among which end clearance between rotor and housing is considered the most important.

5) Difference of pressure between air entrance and discharge of the motor $p_a - p_o = \Delta p_a$ determines input torque to the motor for a particular design. For different size motors operated at the same p_a the torque varies proportional to a size factor $S = e\,R\,L$.

Table III – Critical Pressure Ratios and Flows

k	1.40	1.30	1.20	1.135
ξ_{cr}	0.530	0.546	0.564	0.577
ψ_{max}	0.484	0.473	0.459	0.450

Table IV – NUMERICAL CALCULATION OF TERMS $\left(r = 7, d = \frac{k-1}{k}\right)$

m	r/m	$(r/m)^{d/2}$	$13 \times 10^{-6} (r/m)^{d/2}$	ϕ_{stall}
		For the adiabatic condition $k = 1.4$		
6.5	1.077	1.011	13.15×10^{-6}	0.571
6.0	1.167	1.022	13.30×10^{-6}	0.818
5.5	1.271	1.035	13.45×10^{-6}	1.046
5.0	1.400	1.049	13.65×10^{-6}	1.224
4.5	1.554	1.065	13.85×10^{-6}	1.418
4.0	1.750	1.083	14.10×10^{-6}	1.609
3.7	1.892	1.095	14.22×10^{-6}	1.718
		For the polytropic condition $n = 1.3$		
6.5	1.077	1.009	13.11×10^{-6}	0.738
6.0	1.167	1.018	13.21×10^{-6}	1.063
5.5	1.271	1.028	13.35×10^{-6}	1.338
5.0	1.400	1.039	13.50×10^{-6}	1.592
4.5	1.554	1.052	13.68×10^{-6}	1.833
4.0	1.750	1.067	13.86×10^{-6}	2.081
3.7	1.892	1.076	13.98×10^{-6}	2.235

Table V – Design Constants of Typical Air Motors

	Unit	ξ	z	C
A	Grinder motor	.146	4	1.08
B	Nut Setter motor	.135	4	1.12
C	Screw Driver motor	.188	4	0.81
D	Grinder motor	.183	4	0.76
E	Screw Driver motor	.152	4	0.90

6) For the purpose of this analysis lead in passage flow is treated as flow through a single orifice. This treats the series of orifices and flow passage as if lumped into one fictitious flow area A_H which is also assumed to contain the discharge and flow contraction coefficients. The inverse of A_H can be considered as a flow resistance (dimension of A_H is in²) and A_H is useful in comparing lead-in passage designs.

7) In a similar manner, leakage flow is considered as an orifice flow with a flow area including discharge coefficients equal to A_L.

8) The flow formulas used imply flow from a reservoir where the air is at rest. This is a simplification used to avoid undue complication of the analysis.

9) For the leakage flow the pressure ratio p_a/p_o is above the critical pressure ratio for all practical motors and sonic velocity exists in the leakage passages. Therefore, the leakage flow can be termed "choked".

Analysis

Available line pressure is used in the air motor only to the extent that pressure drop in lead-in passage permits. Lead-in pressure drop is dependent on the rate of flow through the motor, which is a function of dimensional design, motor speed, and leakage flow. Flow resistance in lead-in passages is usually much higher than is desirable. Compactness and reasonable cost in manufacturing are all important but frequently the compromise established is based on insufficient awareness of the magnitude and importance of this factor.

Torque developed by the motor is dependent on counter torque of the load, here called torque requirement. Air pressure across the vanes determines whether this requirement is met. If supply pressure remains unchanged increased torque can be had only by decreasing the pressure drop in lead-in passages so that a greater portion of the line pressure is available at the motor. Reduced total flow rate will accomplish this but the motor slows down.

When leakage flow is large enough to create a pressure drop in the lead-in passages that will leave just enough pressure across the motor vane to meet the torque requirement, no air is left to turn the motor and the motor stalls. Therefore, internal leakage determines stall torque for a given line pressure.

Unlike hydraulic or electric motors, the flow medium in an air motor does not have simple relationships between flow rate, pressure drop and resistance. Rates of discharge for air flow follow the relationships of compressible media, which complicates not only the appearance of the equations, but also their numerical evaluation. To simplify matters a non-dimensional presentation has been chosen, which permits an all-inclusive representation with two graphs and reduces the rest of the work to simple arithmetic.

Inlet Passage Flow

Resistance to flow in the inlet passages causes a drop of line pressure from p_l to p_a. A relationship can be set up between the weight rate of discharge through the inlet passages and the pressure drop across them.

Weight rate of discharge through these passages is identical with the total discharge, G (lb of air per second) and is determined by line pressure p_l, inlet port pressure p_a, density of air, ratio of specific heats and, A_H, the discharge area.

$$G = A_H\, p_l \sqrt{\frac{2g}{R_a T_l}} \left(\frac{p_a}{p_l}\right)^{\frac{1}{k}} \sqrt{\frac{k}{k-1}\left[1 - \left(\frac{p_a}{p_l}\right)^{\frac{k-1}{k}}\right]} \qquad (20)$$

This modification of the general orifice discharge equation is derived in standard texts.

To set this equation in non-dimensional form, pressures are expressed in atmospheres instead of psi and two new variables are defined.

$$\begin{aligned} p_a &= m p_o \\ p_l &= r p_o \\ \frac{p_a}{p_l} &= \frac{m}{r} = \xi \\ d &= \frac{k-1}{k} \\ \psi &= \xi \frac{1}{k} \sqrt{\frac{1}{d}(1 - \xi^d)} \end{aligned} \qquad (21)$$

Substituting Eq. (21) into Eq. (20)

$$G = A_H\, r p_o \sqrt{\frac{2g}{R_a T_l}}\, \xi^{\frac{1}{k}} \sqrt{\frac{1}{d}(1 - \xi^d)} \qquad (22)$$

$$G = A_H\, r p_o \sqrt{\frac{2g}{R_a T_l}}\, \psi \qquad (23)$$

This equation holds for all downstream pressures above critical, that is

$$\xi_{cr} \leqslant \xi \leqslant 1$$

where the critical pressure ratio is

$$\xi_{cr} = \left(\frac{2}{k+1}\right)^{\frac{k-1}{k}} \qquad (24)$$

Therefore, ψ_{max} corresponding to ξ_{cr} is given by

$$\psi_{max} = \left(\frac{2}{k+1}\right)^{\frac{1}{k-1}} \sqrt{\frac{k}{k-1}} \qquad (25)$$

Values of ξ_{cr} and ψ_{max} are solved for several values of k in Table III. Good inlet design will have a pressure drop less than critical. When ξ_{cr} is reached the flow rate is constant.

Leakage Flow

Total weight rate of discharge is split after passing through the inlet passages. One part goes through the motor's volumetric displacement, the other leaks by the vanes doing no useful work. This leakage quantity is by no means a small portion of the total flow. It is assumed that the main portion of leakage occurs between the end clearance of rotor and motor housing and a smaller portion across the seal point between rotor and housing.

Noting that the pressure ratio is $p_o/p_a = 1/m$, the expression for the leakage flow is

$$G_L = A_L\, m\, p_o \sqrt{\frac{2g}{R_g T_o}} \left(\frac{1}{m}\right)^{\frac{1}{k}} \sqrt{\frac{k}{k-1}\left[1-\left(\frac{1}{m}\right)^{\frac{k-1}{k}}\right]} \quad (26)$$

Pressure drop ratio across the motor, 1/m, will nearly always be below the critical pressure ratio and the leakage flow will reach its maximum value with sonic velocity in the clearance space. Therefore

$$\psi_L = \left(\frac{1}{m}\right)^{\frac{1}{k}} \sqrt{\frac{1}{d}\left[1-\left(\frac{1}{m}\right)^{d}\right]}$$

assumes the value ψ_{max} of Eq. (25) and

$$G_L = A_L\, mp_o \sqrt{\frac{2g}{R_g T_o}}\ \psi_{max} \quad (27)$$

Ratio G_L/G can be obtained from Eqs. (22) and (27)

$$\frac{G_L}{G} = \frac{A_L}{A_H}\, \xi^d \sqrt{\frac{T_1}{T_o}}\, \psi_{max} \frac{1}{\sqrt{\frac{1}{d}(1-\xi^d)}} \quad (28)$$

For adiabatic conditions

$$\frac{T_1}{T_o} = (\xi)^{-\frac{k-1}{k}} = \xi^{-d}$$

For polytropic conditions replace k by n.

$$\frac{G_L}{G} = \frac{A_L}{A_H}\, \psi_{max} \sqrt{\frac{d\xi^d}{1-\xi^d}} \quad (29)$$

Theoretical Flow

Motor design dimensions are introduced into the analysis through the ratio of theoretical and total flow. Mass flow is determined by the volumetric displacement of the unit $z V_a$, the density of entering air ρ_a and speed N.

$$G_{th} = \rho_a\, z\, V_a\, N = \frac{z\, V_a\, N}{v_a} \quad (30)$$

Volumetric displacement may be expressed in terms of the design dimensions e, R, L.

$$z\, V_a = C\, 2\pi\, e\, R\, L$$

Where C is a design constant and determined by the location of the air inlet orifice and the number of vanes.

$$G_{th} = \frac{C2\pi\, e\, R\, L\, N}{v_a} = \frac{C2\pi\, e\, R\, L\, N\, (m)^{\frac{1}{k}}}{v_o} \quad (31)$$

Combining Eqs. (31) and (22)

$$\frac{G_{th}}{G} = \frac{C2\pi\, e\, R\, L\, N\, m^{\frac{1}{k}}}{A_H\, v_o\, rp_o \sqrt{\frac{2g}{R_g T_1}} \left(\frac{m}{r}\right)^{\frac{1}{k}} \sqrt{\frac{1}{d}\left[1-\left(\frac{m}{r}\right)^{d}\right]}} \quad (32)$$

Introducing

$$p_o\, v_o = R_g\, T_o$$

$$\frac{T_o}{T_1} = \left(\frac{1}{r}\right)^{d}$$

Then

$$\frac{G_{th}}{G} = \frac{C\, 2\pi\, e\, R\, L\, N}{A_H \sqrt{2g\, R_g\, T_1}} \sqrt{\frac{d}{1-\xi^d}} \quad (33)$$

From the relations of total, theoretical and leakage flow an analytical expression may be derived in non-dimensional form which holds true for any size of air motor under the simplifying assumptions listed above. Continuity requires that

$$G = G_{th} + G_L$$

and

$$\frac{G_{th}}{G} = 1 - \frac{G_L}{G}$$

introducing Eqs. (29) and (33)

$$\frac{C\, 2\pi\, e\, R\, L\, N}{A_H \sqrt{2g\, R_g\, T_1}} \sqrt{\frac{d}{1-\xi^d}} = 1 - \frac{A_L}{A_H}\, \psi_{max} \sqrt{\frac{d\,\xi^d}{1-\xi^d}}$$

Let

$\phi = \frac{A_L}{A_H}$ *Leakage-inlet area ratio.*

$S = e\, R\, L$ *Motor size factor (in³).*

$\Omega = \frac{e\, R\, L}{A_H} = \frac{S}{A_H}$ *Motor-inlet ratio (in.).*

$K = \frac{2\pi}{720} \frac{1}{\sqrt{2g\, R_g\, T_1}}$ *Supply air factor (min/in.).*

Table VI – Design Constants

Motor	A	B	C	D	E
e	0.144	0.159	0.064	0.237	0.095
L	2.75	2.37	1.496	3.50	2.25
eL	0.397	0.377	0.0958	0.831	0.214
m	0.715	0.710	0.174	1.51	0.400
$C_1 = \frac{A_m}{eL}$	1.80	1.88	1.82	1.82	1.87
R	0.986	0.845	0.469	1.296	0.625
R_t	0.972	0.84	0.464	1.29	0.62
R/R_t	1.015	1.005	1.011	1.004	1.007

$$C = \frac{z\,V_s}{2\,\pi\,e\,R\,L} = \frac{z\,V_s}{2\,\pi\,S} \quad \textit{Design constant.}$$

then

$$KC\,\Omega\,N = \sqrt{\frac{1-\xi^d}{d}} - \phi\,\psi_{max}\,\xi^{\frac{d}{2}} \tag{34}$$

In this equation ΩN has the dimensions of velocity and is a relative value for air velocity in the inlet passages. K is constant for a given reservoir temperature. C is determined by eccentricity and the location of intake and discharge ports on the periphery of the motor housing.

Since ξ is an indication of the fraction of the reservoir pressure available to produce torque in the motor, it is advantageous to solve Eq. (34) for various $C\Omega N$ values with ϕ as a parameter. A larger ϕ indicates greater clearance relative to A_H.

Stall and Run Conditions

If the output speed of the motor, N, is zero Eq. (34) becomes

$$\sqrt{\frac{1-\xi^d}{d}} = \phi\,\psi_{max}\,\xi^{\frac{d}{2}}$$

and solving for ϕ,

$$\phi = \frac{1}{\psi_{max}}\sqrt{\frac{\left(\frac{r}{m}\right)^d - 1}{d}} \tag{35}$$

When running, N is not zero and Eq. (34) becomes

$$\phi = \frac{1}{\psi_{max}}\sqrt{\frac{\left(\frac{r}{m}\right)^d - 1}{d}} - \frac{K}{\psi_{max}}(C\,\Omega\,N)\left(\frac{r}{m}\right)^{\frac{d}{2}} \tag{36}$$

Assuming

$$r = 7 \qquad (p_i = 105\ psia)$$

$$\psi_{max} = 0.484 \qquad (k = 1.4)$$

$$d = 0.286$$

$$\phi = 3.86\sqrt{\left(\frac{r}{m}\right)^4 - 1} - 13 \times 10^{-4}\,(C\,\Omega\,N)\left(\frac{r}{m}\right)^{\frac{4}{3}} \tag{37}$$

This equation holds for values of

$$\frac{r}{m} \leqslant \frac{1}{0.528} = 1.88$$

$$m \geqslant 3.7$$

At the value of $m = 3.7$ choking sets in and no increase of flow takes place across the inlet orifice.

A plot of Eq. (37) is shown in Fig. 6 of ϕ versus m with $C\Omega N$ as parameter. Fig. 7 is a graphical presentation of the same equation plotting m versus $C\Omega N$ with ϕ as the parameter. As plotted in Fig. 7 the family of curves have the same relative shapes as the idealized input torque-speed curves of a "unit" motor. Each curve has a fixed A_L/A_H ratio and as speed increases useful pressure across the vanes (p_e), which is equivalent to output torque, drops. Numerical values for these plots are given in Table IV for $k = 1.3$ as well as $k = 1.4$ as plotted.

Design Constants

In order to interpret these curves in terms of a particular design, C and Ω have to be evaluated and introduced. The

value of C will always be smaller than 2.0 and will decrease as the entrance orifice is shifted toward the seal point and the number of vanes is increased. Table V lists C for a number of typical designs.

The value for Ω may lie between 5 and 25. To find the family of values of CΩN for a range of speeds enter the lower graph of Fig. 7 at the left and follow it horizontally. As it intersects each speed a value of CΩN is read or used directly in the graph above.

Input Torque

From the analysis of a vane motor average input torque may be written as

$$T_{in} = \Delta p_m \, A_m \, R_t \tag{38}$$

in which

$$A_m = C_1 \, e \, L$$

$$R_t = C_2 \, R$$

Mean pressure difference acting across the vanes, Δp_m may be expressed with sufficient accuracy by

$$\Delta p_m = C_3 \, \Delta p_a = C_3 \, (m-1) \, p_a$$

Therefore

$$T_{in} = C_1 \, C_2 \, C_3 \, e \, R \, L \, (m-1) \, p_a \tag{39}$$

A check of $C_3 = R_t/R$ shows C_3 less than 1 per cent from unity and the equation can be simplified by letting $C_3 = 1.00$. Introducing a new variable

$$T = \frac{T_{in}}{e \, R \, L \, p_a} = \frac{T_{in}}{S p_a} \tag{40}$$

$$T = (m-1) \, C_1 \, C_2 \tag{41}$$

Values of C_1 and C_2 on a number of typical air motors are nearly identical as shown in Table VI. In this table values of $R/R_L \, (= C_3)$ are also tabulated.

The value for $C_2 = \Delta p_m / \Delta p_a$ can be found from the p–V diagram and it depends on the volumetric expansion ratio. Choosing average values for $C_1 = 1.84$, $C_2 = 0.89$ and letting $C_3 = 1.00$.

$$T = 1.64 \, (m-1) \tag{42}$$

Hence the graphs of Figs. 6 and 7 may be equipped with a scale for T proportional to $(m-1)$. Torque input may then be computed from Eq. (40).

Numerical Applications

It must be emphasized that the theory underlying these graphs is considerably simplified and agreement with experimentally determined performance curves will be more or less approximate. The main advantage of this analysis and the graphical presentation lies in showing relative changes in the performance caused by changes in the leakage, inlet passage area, and the basic dimensions of the unit, e, R and L.

Assuming a unit with (first unit signified by index 1).

$$\phi_1 = A_L / A_H = 0.5$$

$$\Omega = e \, R \, L / A_H = 6$$

$$C = z \, V_a / 2 \pi \, e \, R \, L = 1.0$$

For a speed of 5000 rpm and $(C\Omega N) = 3 \times 10^4$, T_1 can be found from Fig. 7.

$$T_1 = 7.87$$

$$m_1 = 5.80$$

If this unit is compared with another one of the same size and design which has twice the clearance or leakage area A_L,

$$\phi_2 = 1.0$$

then for $N = 5000$, $C\Omega N = 3 \times 10^4$

and

$$T_2 = 5.0$$

$$m_2 = 4.50$$

Hence

$$\frac{(T_{in})_2}{(T_{in})_1} = \frac{T_2}{T_1} = \frac{5.75}{7.87} = 0.73$$

$$= \frac{(m-1)_2}{(m-1)_1} = \frac{3.5}{4.80} = 0.73$$

$$\frac{(p_a)_2}{(p_a)_1} = \frac{m_2}{m_1} = \frac{4.5}{5.80} = 0.78$$

This shows that an increase in leakage by a factor of two decreases the input torque by approximately 27 per cent.

If unit 1 is compared with a unit 3 having a motor twice as long but using the same inlet passages, such that

$$L_3 = 2L_1$$

$$(A_H)_3 = (A_H)_1$$

but maintaining the same clearances and leakage.
then

$$\phi_3 = 0.5$$

$$\Omega_3 = 12$$

$$C = 1.0$$

and for $N = 5000$ rpm, $C_\omega N = 6 \times 10^4$

$$T_3 = 6.12$$

$$m_3 = 4.74$$

$$\frac{(T_{in})_3}{(T_{in})_1} = \frac{T_3 \, \Omega_3}{T_1 \, \Omega_1} = \frac{6.12 \times 2}{7.87} = 1.55$$

Consequently, 100 per cent increase in torque cannot be expected by a 100 per cent increase of the motor length if the inlet flow area is unchanged because of the higher pressure drop.

However, if the inlet is opened up such that

$$(A_H)_4 = 2 \, (A_H)_1$$

$$\Omega_4 = 3C \, \Omega \, N = 1.5 \, (10^4)$$

$$\phi_4 = 0.25$$

then

$$T_4 = 9.31$$

$$m_4 = 6.68$$

and

$$\frac{T_4}{T_1} \quad \frac{(m-1)_4}{(m-1)_1} = 1.17$$

$$(T_{in})_4 = 1.17 \, (T_{in})_1$$

By decreasing the inlet flow resistance to half the value of motor 1 but otherwise keeping the motor unchanged, an increase in input torque of 17 per cent can be expected.

Speed-Torque Analysis

For Complex Mechanical Systems

Systematic method for analyzing complex rotating mechanical systems, including effects of friction in bearings, inertia of components and angular deflection in shafts.

V. H. SELIGER
Engineering Department Head
Ford Instrument Company

BY ASSUMING AN "IDEAL" SYSTEM, as discussed in the preceding article, December 1956, page 184, a quick approximation can be obtained of the speed-torque relationships in the system. In such a system it is assumed that the elements neither store, generate, or dissipate energy.

Actual rotating systems, however, involve friction in bearings, inertia of components, and deflection in shafts which cause time lags, stray torques and angular deflections within the system. Since there are an infinite number of combinations of elements possible, it is seldom feasible to use a previously derived set of equations. Each system has to be solved individually—first setting up a series of equations relating subdivided sections of the system, then deriving final equations relating output to input speeds and torques.

Thus, to extend the "ideal" analysis to a practical system, three factors—friction, inertia and compliance—are isolated and incorporated into the method previously discussed.

Power Flow

To express the directional relationships involved, applied torque at a terminal of a device is considered clockwise when the terminal acceleration resulting from replacement of the device by a purely inertial load would be clockwise. Therefore, when the applied torque at a terminal of a device is in the same direction as the angular velocity at the terminal, power is delivered to the device through the terminal; when the applied torque and velocity directions are opposite, power is removed from the device through the terminal.

Positive directions of applied torque T and speed ω are always assigned so that if torque is positive when clockwise at a terminal, speed at that terminal will also be positive when clockwise. Thus,

$T\omega > 0$ Power is delivered to device through terminal;
$T\omega < 0$ Power is removed from device through terminal.

Analysis of an Ideal System

In the treatment of ideal systems, discussed in the earlier article, the following steps were employed:

1. Divide the system into parts, such that each part contains one and only one element.

2. Assign directions of positive motion to each terminal of each device.

3. Write the angular velocity equations for each device, employing algebraic signs as determined by the geometry of the device and the assignments made in Step 2.

4. Write the torque equations for each device, again in terms of the assignments made in Step 2.

5. Write for each junction of two terminals, or "cut," the applicable pair of equations, either (1) or (2), below:

$$\omega_L = \omega_R, \qquad T_L = -T_R \tag{1}$$

or

$$\omega_L = -\omega_R, \qquad T_L = T_R \tag{2}$$

where subscripts L and R refer to terminals to the left and right of the cut.

6. Solve equations of Steps 3, 4, and 5 for the unknown variables in terms of the known. Begin by eliminating the variable on one side of each of the junction equations of Step 5.

To include consideration of friction, inertia, and compliance, three new elements, together with their torque and speed equations are introduced.

Friction, Inertia, and Compliance

Friction element shown at (A) in Fig. 1, is defined as a two-terminal element consisting of an inertialess, perfectly rigid rotating part against which a frictional torque T_F is exerted.

The algebraic sum of the power flowing into both ends of the friction element is always positive. Therefore:

$$T_1\omega_1 + T_2\omega_2 = P_F \tag{3}$$

where P_F is the rate of energy loss by friction, and is always positive, regardless of the direction of rotation; and where subscripts 1 and 2 refer to terminals 1 and 2 respectively. If the frictional torque T_F is known, Eq (3) may be rewritten as:

$$T_1\omega_1 + T_2\omega_2 = |\, T_F\omega_1 \,| \tag{4}$$

or

$$T_1\omega_1 + T_2\omega_2 = |\, T_F\omega_2 \,| \tag{5}$$

Both equations are always applicable, the absolute value

sign properly accounting for the sign of the right-hand side in each case, regardless of the choice of positive direction at 1 and 2. Naturally, use will be made of the relation $\omega_1 = \omega_2$ or $\omega_1 = -\omega_2$ in determining T_1 and T_2.

Inertia element shown at (B) in Fig. 1 is defined as a two-terminal element consisting of a frictionless, perfectly rigid rotating part having inertia I.

In treating the inertia element, arbitrary assignments for positive direction of terminal motion cannot be used, and the positive direction of motion at terminal 1 is taken to correspond to the positive direction of motion at terminal 2. Thus when motion is positive or negative at terminal 1 it must be positive or negative at terminal 2. (Positive motion direction at a terminal is still to be taken as that of both positive torque and velocity). Therefore,

$$\omega_1 = \omega_2 = \omega$$

$$T_1\omega + T_2\omega = \text{rate of energy storage}$$

$$T_1\omega + T_2\omega = I\omega\,\frac{d\omega}{dt}$$

$$T_1 + T_2 = I\,\frac{d\omega}{dt} \qquad (6)$$

Compliance is the angular deflection (twist) of a shaft per unit of torque and is therefore the reciprocal of rotational stiffness or 1/K, where K is the torsional spring constant equal to T/θ. Perfect rigidity implies that K is infinite or that compliance is equal to zero.

A compliance element is shown in (C) of Fig. 1. It is defined to be a two-terminal element consisting of a frictionless, inertialess rotating part having a torsional spring constant equal to K.

As in the case of the inertia element, completely arbitrary directions for positive terminal motion cannot be assigned. For the compliance element, however, positive direction of motion at terminal 1 is taken to correspond to negative motion direction at terminal 2. However, positive motion direction at a terminal is still taken to be that of both the positive torque and velocity.

Presence of compliance in the element implies an angular position difference θ between terminals 1 and 2. A given value of either ω_1 or ω_2 results in an identical rate of change of θ. Therefore, positive direction of θ can be assigned to correspond to positive ω_1 and/or ω_2.

From consideration of angular momentum, and since $I = 0$.

$$T_1 - T_2 = \frac{d}{dt}\,(I\omega_1) = 0$$

or

$$T_1 = T_2$$

also,

$$\omega_1 + \omega_2 = \frac{d\theta}{dt}$$

From energy considerations,

$$T_1\omega_1 + T_2\omega_2 = \text{(rate of energy storage)}$$

therefore

$$T_1\omega_1 + T_2\omega_2 = \frac{d}{dt}\left(\frac{K\theta^2}{2}\right) = K\theta\,\frac{d\theta}{dt} = K\theta(\omega_1 + \omega_2)$$

or

$$\frac{dT_1}{dt} = \frac{dT_2}{dt} = K\,\frac{d\theta}{dt} = K(\omega_1 + \omega_2) \qquad (7)$$

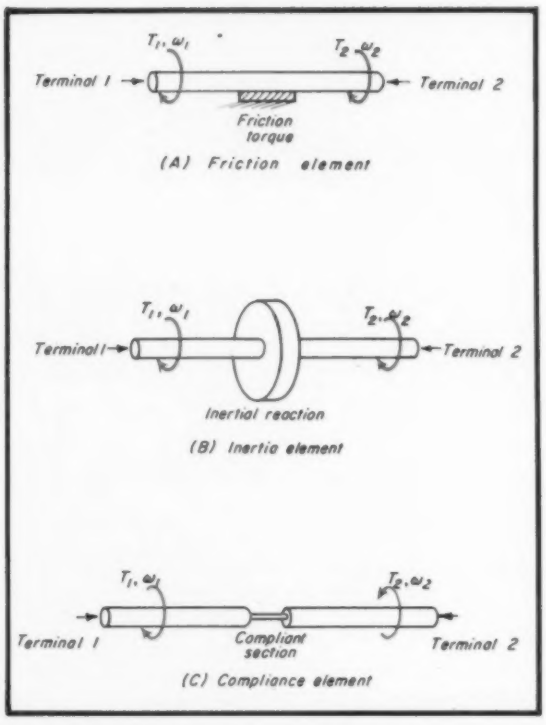


Fig. 1—Directions of positive motion as assigned to (A) friction elements, (B) inertia elements, and (C) compliance elements.

Complex Systems

Having defined the friction, inertia, and compliance elements, and determined their torque equations, any complex system can now be analyzed which can be reduced to a number of these elements, plus a number of "ideal" devices. Steps by which this may be accomplished are as follows:

Step 1: Divide the system into parts, so that each part contains only one element, each element being either an "ideal" device or a friction, inertia, or compliance element. Ideal devices may be of multi-terminal nature; for example, a differential has three terminals.

Step 2: Assign a direction of positive motion to each terminal of each element exactly as is done in ideal systems, excepting for the two restrictions noted below. In all cases, direction of positive motion at each terminal is the direction both of positive applied torque and of positive angular velocity at the terminal.

Assignment of positive directions may be made arbitrarily, with the following restrictions:

a) Direction of positive motion at one terminal of each inertia element must correspond to the direction of positive motion at the other terminal.

b) Direction of positive motion at one terminal of each compliance element must correspond to the direction of negative motion at the other terminal.

Step 3: Write the angular velocity and torque equations for each ideal device, exactly as in the ideal system case.

Step 4: For each friction element (except those of which only one terminal is connected in the system), write the

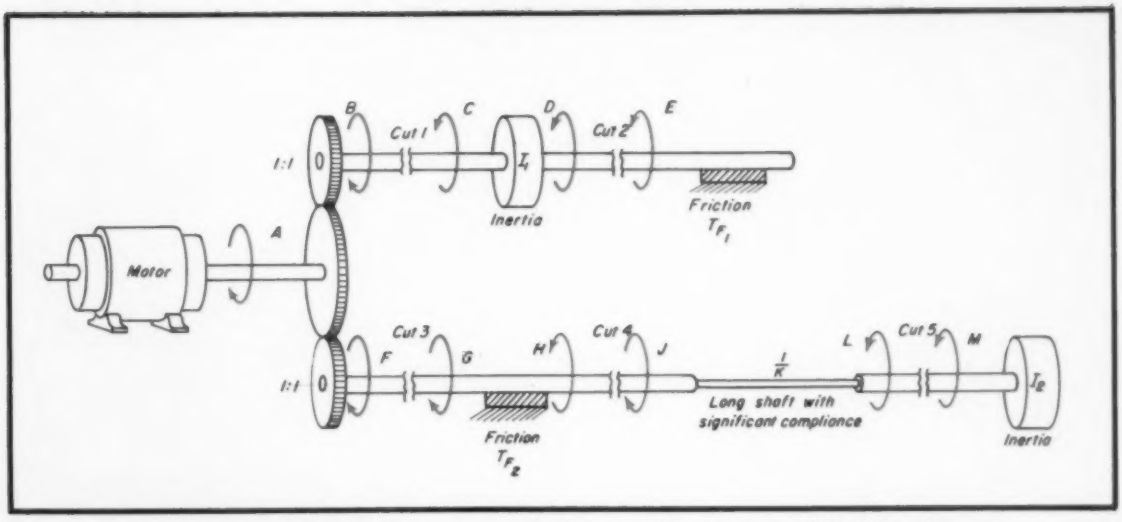


Fig. 2—Typical mechanical rotating system analyzed for speed and torque relationships. System is divided into six subdivisions by Cuts 1 to 5. Non-ideal elements are classified as being friction, compliance or inertia elements and incorporated into suitable equations as illustrated in sample problem. Directions of motion are assigned in accordance with prescribed rules.

applicable one of the following equations:

$$\omega_1 = \omega_2 \tag{8}$$

or

$$\omega_1 = -\omega_2 \tag{9}$$

where ω_1 and ω_2 are angular velocities at terminals 1 and 2 of the friction element.

In addition, for each friction element, write an equation corresponding either to Eq (3), (4), or (5) as convenient. For example, if T_F is known as a function f of ω_2, it may be convenient to write Eq (5) as:

$$T_1\omega_1 + T_2\omega_2 = |\ \omega_2 f(\omega_2)\ |$$

Step 5: For each inertia element, write

$$\omega_1 = \omega_2$$

and

$$T_1 + T_2 = I\frac{d\omega_1}{dt} = I\frac{d\omega_2}{dt}$$

Step 6: For each compliance element, write

$$T_1 = T_2$$

and

$$\frac{dT_1}{dt} = \frac{dT_2}{dt} = K(\omega_1 + \omega_2)$$

Step 7: For each junction of two terminals, or "cut," write the applicable pair of equations, either Eqs (1) or (2).

Step 8: Eliminate the variable on one side of each of the junction equations of Step 7 by substitution of the other side wherever the first side appears in the torque and speed equations of Steps 3 to 7.

Step 9: Combine the remaining equations to form the differential equations of motion of the system, which may be solved by standard methods for the motions and torques of the elements.

Sample Problem

System shown in Fig. 2, although somewhat simplified, will serve to illustrate the method. Procedure is as follows:

Step 1: Division is made by "cuts," as shown in the figure.

Step 2: Positive motion direction are assigned as shown by the arrows. Note that arrow directions are the same at points *C* and *D*, and are opposite at points *J* and *L*, in accordance with the restrictions for inertia and compliance elements.

Step 3: The only "ideal" device is the pair of 1:1 gear ratios, which together constitute a "tee" connection (the gears are considered inertialess).

thus:

$$T_A\omega_A + T_B\omega_B + T_F\omega_F = 0 \tag{10}$$

also,

$$\omega_A = -\omega_B = -\omega_F \tag{11}$$

from which

$$T_A\omega_A - T_B\omega_A - T_F\omega_A = 0$$

or

$$T_A = T_B + T_F \tag{12}$$

Step 4: Between cuts 3 and 4:

$$\omega_G = -\omega_H \tag{13}$$

$$T_G\omega_G + T_H\omega_H = |\ T_{F2}\omega_G\ |$$

or

$$(T_G - T_H)\omega_G = |\ T_{F2}\omega_G\ |$$

Assume T_{F2} to be a viscous friction torque such that

$$T_{F2} = \rho_2\omega_G$$

where ρ is the coefficient of viscous friction and is always greater than zero.

then

$$|\ T_{F2}\omega_G\ | = \rho_2\omega_G^2$$

and

$$T_G - T_H = \rho_2\omega_G \tag{14}$$

To the right of cut 2:

$$T_E\omega_E = |\ T_{F1}\omega_E\ |$$

Assuming as before that:

$$T_{F1} = \rho_1\omega_E \quad \text{where} \quad \rho_1 > 0$$

then

$$T_E = \rho_1 \omega_E \tag{15}$$

Step 5: Between cuts 1 and 2:

$$\omega_C = \omega_D \tag{16}$$

$$T_C + T_D = I_1 \frac{d\omega_C}{dt} \tag{17}$$

To the right of cut 5:

$$T_M = I_2 \frac{d\omega_M}{dt} \tag{18}$$

Step 6: Between cuts 4 and 5

$$T_J = T_L; \quad \frac{dT_J}{dt} = \frac{dT_L}{dt} = K(\omega_J + \omega_L) \tag{19}$$

Step 7: Cut 1:

$$\omega_B = -\omega_C; \qquad T_B = T_C \tag{20}$$

Cut 2:

$$\omega_D = \omega_E; \qquad T_D = -T_E \tag{21}$$

Cut 3:

$$\omega_F = \omega_G; \qquad T_F = -T_G \tag{22}$$

Cut 4:

$$\omega_H = -\omega_J; \qquad T_H = T_J \tag{23}$$

Cut 5:

$$\omega_L = \omega_M; \qquad T_L = -T_M \tag{24}$$

Step 8 and 9: Eliminate left-hand terms of Eqs. (20) through (24) and use Eqs (11) to (19) to obtain the following torque equations:

$$T_J = -I_2 \frac{d\omega_M}{dt} \tag{25}$$

$$T_G = \rho_2 \omega_G - I_2 \frac{d\omega_M}{dt} \tag{26}$$

$$T_C - \rho_1 \omega_E = I_1 \frac{d\omega_C}{dt} \tag{27}$$

$$T_C - \rho_1 \omega_E = T_C + \rho_1 \omega_G = -I_1 \frac{d\omega_G}{dt} \tag{28}$$

$$T_A = I_2 \frac{d\omega}{dt} M - (\rho_1 + \rho_2)\omega_G - I_1 \frac{d\omega_G}{dt} \tag{29}$$

Since the motor torque T_A is assumed to vary as a function of time, Eq (29) is in two unknowns, ω_M and ω_G. All other velocities can be found from equations involving ω_M and ω_G by simple substitution.

The second necessary equation is found as follows:

$$\omega_M + \omega_G = \omega_M + \omega_J = \frac{1}{K}\frac{dT_J}{dt} = -\frac{1}{K} I_2 \frac{d^2\omega_M}{dt^2}$$

or

$$\omega_G = -\omega_M - \frac{1}{K} I_2 \frac{d^2\omega_M}{dt^2} \tag{30}$$

therefore

$$\frac{d\omega_G}{dt} = -\frac{d\omega_M}{dt} - \frac{1}{K} I_2 \frac{d^3\omega_M}{dt^3} \tag{31}$$

Substituting (30) and (31) in (29),

$$T_A = I_2 \frac{d\omega_M}{dt} + (\rho_1 + \rho_2)\left(\omega_M + \frac{I_2}{K}\frac{d^2\omega_M}{dt^2}\right) + I_1\left(\frac{d\omega_M}{dt} + \frac{I_2}{K}\frac{d^2\omega_M}{dt^2}\right)$$

thus resulting in the following differential equation:

$$T_A = \frac{I_1 I_2}{K}\frac{d^3\omega_M}{dt^3} + \frac{I_2}{K}(\rho_1 + \rho_2)\frac{d^2\omega_M}{dt^2} + (I_1 + I_2)\frac{d\omega_M}{dt} + (\rho_1 + \rho_2)\omega_M \tag{32}$$

In a typical application, the values of I_1, I_2, K, ρ_1 and ρ_2 are specified; the input torque T_A is also a specified function of time. Equation (32) can therefore be solved under given initial conditions for the value of output speed ω_M as a function of time. Values of the other speeds and torques in the system can be found in a similar manner.

For example, one can solve for the maximum torque at any point resulting from a sudden reversal of the motor torque. In addition, final differential equations derived by the above method can be used to determine the critical (resonant) frequencies of the system at which small disturbances can cause large torsional deflections and stresses.

Controlling Vibration in Rotating Machinery

In order to reduce vibration to a minimum, it is necessary that the normal operating speed of the machine be sufficiently different from all its critical speeds, these in turn being dependent on the critical speeds of the machine's components. Other speeds of rotation to be avoided for various reasons include double any critical speed, half the first or third critical speed, and often half the second critical speed. Additional variables to be taken into account include differences between the vertical and horizontal elastic characteristics of the supports.

This multiplicity of speeds to be avoided makes it difficult to design a rotating machine to run at a predetermined speed. One way is to find means of changing some of the critical speeds of the machine.

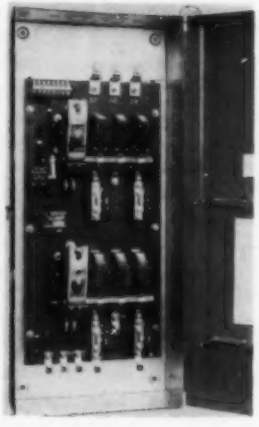
One such method consists in changing the rigidity characteristics of the rotor supports by backing the shaft bearings with specially designed inserts. These inserts use different materials to obtain special elastic characteristics; they are introduced into the machine after it has been assembled and test-run, and after the critical speeds of the individual machine have been determined. The method is described in "Les groupes turbo-alternateurs de grande puissance et le problemè des vibrations," by P. Destival and J. Chaboseau in Revue Générale de Mécanique, Paris (France), December 1955.

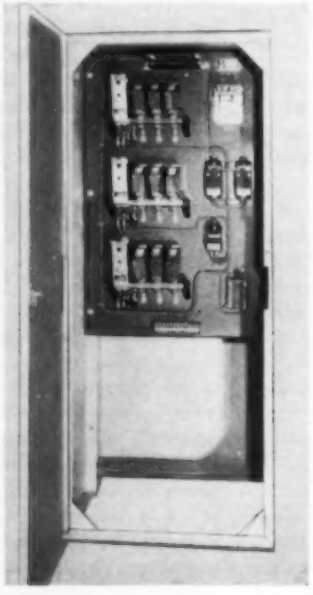
With an absolutely rigid and separately supported shaft, amplitude of oscillation at the first critical speed approaches a value which is a function of the mass, speed and eccentricity of the rotor. Decreasing the rigidity of the shaft lowers the critical speed of the rotor.

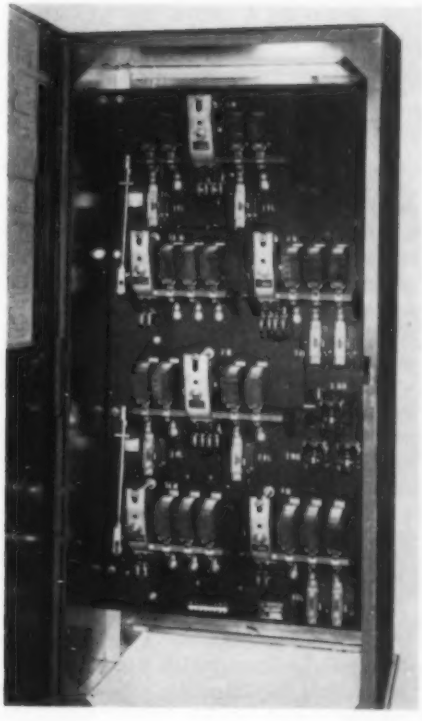
Assuming the rotor mounted on non-rigid supports, deformation of the supports is a function of the speed of rotation of the rotor and of the elasticity of the supports.

Mounting the rotor on supports integral with or rigidly fixed to the stator, reduces considerably the amplitude of vibration of the supports. In such a case, the critical speeds of the assembly are approximately the same as the critical speeds of the individual components.

WHERE CONTINUOUS speed adjustment is not necessary, speed control in fixed ratios is provided by multispeed motors. Controllers for multispeed motors provide the various connections needed combined with overload protection. Where currents vary widely at different speeds, different sizes of contactors may be used in a single controller. Overload protection is usually by thermal relays. Examples of typical controllers shown here are: (A) a two-speed controller for a 100-hp 220-volt motor with a single winding and constant torque characteristics; (B) a two-speed controller for a squirrel cage motor with two independent windings; (C) a four-speed controller for a 200-hp 440-volt motor.







Controls for MULTISPEED MOTORS

Basic characteristics of two-, three-, and four-speed squirrel-cage induction motors; manual, sequential, and compelling operation of multispeed controllers; relative costs, and application examples.

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SPEED OF MACHINES driven with squirrel cage motors is usually varied by mechanically changing the coupling between motor and load. For applications where precise speed adjustment is not required and where the load speed changes are whole number ratios such as 2:1, 3:1, or 3:4, use of multispeed motors and controllers can save space, reduce mechanical and electrical complexities, and may also reduce cost.

Multispeed Motors

Multispeed motors are constructed with stator windings which can be connected and reconnected to change the number of electrical poles produced. For 60-cycle motors, speeds obtainable with various numbers of poles are shown in Table I. Multispeed motors are usually limited to 2, 3, or 4 speeds; in Table I standard speeds are shown in color, but other combinations are available.

Torque and horsepower of multispeed motors correspond to those of standard NEMA designs. They are available with either torque or horsepower constant for all speeds, or with torque and horsepower which varies with the speed. In constant-torque motors horsepower varies directly with the speed. These motors are generally used in feeders, mills, and conveyers. Constant horsepower motors deliver rated horsepower at all of the speeds for which the motor is designed. In this case torque varies inversely with speed. This type is used in machine-tool applications where motor speed governs speed of cutting tool. Variable torque motors have a horsepower output which changes as the square of the speed. They are applicable only to drives having fan or centrifugal load characteristics.

Multispeed motors are available in enclosures corresponding to those listed for standard NEMA single-speed

TABLE I—Variation of 60-Cycle Induction Motor Speeds With No. of Poles. Most common speeds are shown in color.

Number of Poles	RPM	Number of Poles	RPM
2	3600	14	514
4	1800	16	450
6	1200	18	400
8	900	20	360
10	720	22	327
12	600	24	300

motors, including open drip-proof, splash-proof, enclosed, and vertical type. Except for the stator winding, construction is the same. Three types of stator windings are used—single, two independent, and two interconnected windings. In the single-winding, two speeds are obtained by regrouping the poles; in this case, low speed is one half of high. For the motor with two independent windings, a separate nonrelated speed can be obtained from each winding; this permits a wide choice of speed combinations, not necessarily related to 2:1. The two-winding motor in which both windings are designed to be interconnected in three or four combinations, provides three or four speeds.

Typical speeds and torque-hp combinations obtainable from the three types of stator windings are shown in Table II. Motor connections are also included.

Two-speed Motors

In motors having a single multispeed winding, all of the winding is energized at each speed. In a motor with independent windings, the winding corresponding to the operating speed is used. Motors with independent windings are usually more expensive than the single. However, controllers for independent-winding motors are less expensive while the controllers for the single winding units are more expensive. Single windings can only be used when the ratio of high speed to low speed is 2 to 1. Line connections for two-speed, single-winding motors of constant-hp or constant or variable torque are in Table II.

If the speed ratio differs from 2 to 1, independent windings are normally required. For example, for operating speeds of 1200 and 900 rpm, two independent windings would be used. Line connections for a two-speed independent winding motor are shown in Table II. These connections are suitable for constant horsepower, constant torque, or variable torque characteristics as designed into a particular motor.

Three and Four-Speed Motors

Separate designs are required for constant horsepower, constant or variable torque characteristics in three- and four-speed motors. Three-speed motors usually have one dual-speed and one single-speed winding. Connections for three-speed motors are shown in Table II. Four-speed motors usually contain two dual sets of windings; these are also shown in Table II. Closed or delta windings are always broken when the motor is being operated on any of the remaining windings.

Multispeed Motor Controllers

The various connections between power line and motor for the two or more speeds and overload protection for all speeds are provided by the controllers for these motors. These controllers are usually magnetically operated two-, three-, or four-pole contactors, together with required low-voltage control circuits. Controller size varies with the hp rating of motor used and is indicated in Table III. Where currents vary greatly at different speeds, different sizes of contactors may be used in a single controller.

Controllers for multispeed motors can provide simple manual control of starting, speed-changing, and stopping; they can be also obtained with automatic sequential starting, with compelling speed transfer or a combination of both. Because starting currents of constant-hp motors are nearly equal for the different speeds, automatic sequence starting is normally not used unless the starting shock on the machine or load must be minimized.

Starting currents of constant- and variable-torque motors vary with each speed; where starting-current limitations are required, standard reduced-voltage starting methods using autotransformers, reactors and resistors may be used. These were described in detail in "Starting Methods for Three-phase Motors", February 1956 page 183. However, reduced-voltage starting of multispeed motors increases controller complexity and adds substantially to the cost.

Compelling transfer or control is used to prevent accidental plugging when going from a higher speed to a lower speed. Compelling, or time delay relays, (such as described in "Pneumatic Time Delay Relays" January 1956 page 173) are used to introduce a delay sufficient to allow the motor to slow down to the next lower speed before reconnecting the motor to the line. Time delay relays are normally used because they are less costly and complicated than other means. However, they must be adjusted for the correct delay when the equipment is put in service.

A time delay can also be obtained by using speed switches connected to the motor shaft. In this case the switches operate when the motor has coasted to the next lower operating speed. A compelling transfer controller for a three- or four-speed motor with required delays between each higher to lower speed is feasible but is complex and expensive.

Overload protection for multispeed motors is usually of the thermal type. Overload relays are normally inserted into the motor terminal leads for the corresponding speed connections. This is shown in Fig. 1, the control diagram for a two-speed independent-winding squirrel cage motor controller.

For low currents and voltages below 600 overload relays

Table III—Maximum Hp Ratings for Low Voltage 3-phase Controllers For Single- and Multi-Speed Induction Motors.

NEMA Controller Size	Single Speed		2, 3, and 4 Speeds					
			Constant Hp.		Constant Torque		Variable Torque	
	220 V	440 V	220 V	440 V	220 V	440 V	220 V	440 V
0	2	3	1½	2	2	2	2	2
1	5	7½	3	5	5	7½	5	7½
2	15	25	10	20	15	25	15	25
3	30	50	20	40	30	50	30	50
4	50	100	30	60	50	100	50	100
5	100	200	75	150	100	200	100	200

Multispeed Motor Connections Required to Obtain the Various Speeds for Different Number and Types of Windings and for Different Torque and Hp Characteristics

Table II

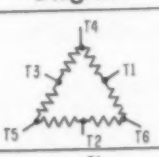
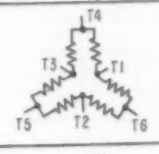
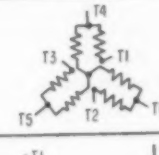
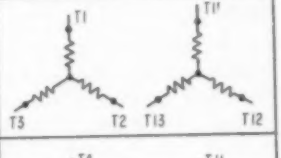
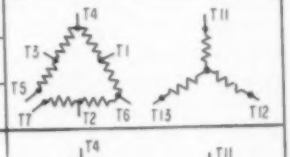
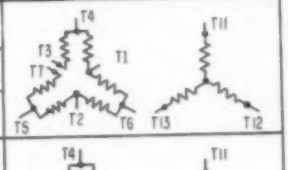
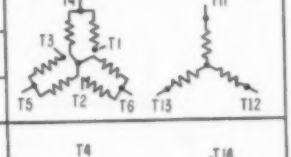
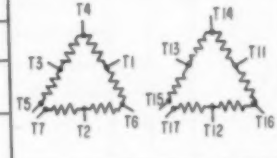
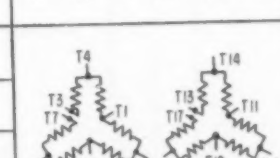
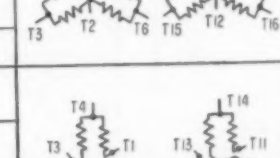
No. of Speeds	No. of Windings	Typical Speeds, rpm	Torque-Hp Characteristics	Speed	External Motor Connections					Motor Winding Diagram
					Line			Other		
					L1	L2	L3	Open	Shorted	
2	1	600 1200	Constant Hp	Low	T1	T2	T3		T4, T5, T6	
				High	T6	T4	T5	T1, T2, T3		
			Constant Torque	Low	T1	T2	T3	T4, T5, T6		
				High	T6	T4	T5		T1, T2, T3	
			Variable Torque	Low	T1	T2	T3	T4, T5, T6		
				High	T6	T4	T5		T1, T2, T3	
	2 independent	900 1200	Constant Hp and Torque Variable Torque	Low	T1	T2,	T3	T11, T12, T13		
				High	T11	T12	T13	T1, T2, T3		
3	2 Interconnected	600 900 1200	Constant Hp	Low	T1	T2	T3	T11, T12, T13	T4, T5, T6, T7	
				Interm	T11	T12	T13	T1, T2, T3 T4, T5, T6, T7		
				High	T6	T4	T5, T7	T1, T2, T3, T11, T12, T13		
			Constant Torque	Low	T1	T2	T3, T7	T4, T5, T6 T11, T12, T13		
				Interm	T11	T12	T13	T1, T2, T3 T4, T5, T6, T7		
				High	T6	T4	T5	T11, T12, T13	T1, T2, T3, T7	
			Variable Torque	Low	T1	T2	T3	T4, T5, T6 T11, T12, T13		
				Interm	T11	T12	T13	T1, T2, T3 T4, T5, T6		
				High	T6	T4	T5	T11, T12, T13	T1, T2, T3	
4	2 interconnected	600 900 1200 1800	Constant Hp	Low	T1	T2	T3	T11, T12, T13, T14, T15, T16, T17	T4, T5, T6, T7	
				1st Interm	T11	T12	T13	T1, T2, T3, T4, T5, T6, T7,	T14, T15, T16, T17	
				2nd Interm	T6	T4	T5, T7	T1, T2, T3, T11, T12, T13, T14, T15, T16, T17		
				High	T16	T14,	T15, T17	T1, T2, T3 T4, T5, T6, T7 T11, T12, T13		
			Constant Torque	Low	T1	T2	T3, T7	T4, T5, T6, T11, T12, T13, T14, T15, T16, T17		
				1st Interm	T11	T12	T13, T17	T1, T2, T3, T4, T5, T6, T7, T14, T15, T16		
				2nd Interm	T6	T4	T5	T11, T12, T13, T14, T15, T16, T17	T1, T2, T3, T7	
				High	T16	T14	T15	T1, T2, T3, T4, T5, T6, T7	T11, T12, T13, T17	
			Variable Torque	Low	T1	T2	T3	T4, T5, T6, T11, T12, T13, T14, T15, T16		
				1st Interm	T11	T12	T13	T1, T2, T3, T4, T5, T6, T14, T15, T16		
				2nd Interm	T6	T4	T5	T11, T12, T13, T14, T15, T16	T1, T2, T3	
				High	T16	T14	T15	T1, T2, T3, T4, T5, T6,	T11, T12, T13	

Table IV—Relative Costs of Magnetic Controllers for Single and Multispeed Squirrel Cage Motors

Controller for Motor Type	NEMA Controller Sizes					
	0	1	2	3	4	5
Single Speed	100%	100%	100%	100%	100%	100%
2 Speeds, 2 Independent Wingings	300%	300%	300%	200%	250%	300%
2 Speeds, 1 Winding	400%	400%	350%	300%	400%	350%
3 Speeds, 2 Windings	1000%	1000%	750%	600%	700%	
4 Speeds, 2 Windings	1500%	1450%	1100%	1000%	1100%	

are usually of the direct series type. For high current and voltage the relays are operated from the secondaries of current transformers. Some circuits employ a single set of current transformers located in the incoming power lines to operate all of the overload relays for the various speeds. With this arrangement, relays with low current ratings for the low speed connections are automatically bypassed when the motors are operated at the higher speed connections and greater full-load currents. This particular arrangement is illustrated in Fig. 2 which shows a control diagram for a two-speed single-winding constant-torque controller. The control circuit provides for high and low speed operation in the forward direction and low speed only in the reserve direction.

Multispeed motor controllers can also be provided with all of the other protective features used for single-speed motors, such as open-phase, phase-reversal, and three-phase overload.

Controller Costs

Multispeed controllers are more complex than single-speed, requiring circuits especially designed for proper sequencing and adequate mechanical and electrical interlocking to prevent simultaneous closing of contactors which can damage motors or machines or produce short circuits across the power lines. For this reason they are more costly, as shown in Table IV, which compares relative costs of single and multispeed controllers. List prices of multispeed controllers usually do not include compelling features, automatic accelerating and decelerating features, or protective features other than two-phase overload and low-voltage protection or release. The prices for other protective features are comparable to those for single speed controllers.

Because machinery and power system shocks become more significant on the larger sizes, compelling-type controllers are recommended for size 3 controllers and over,

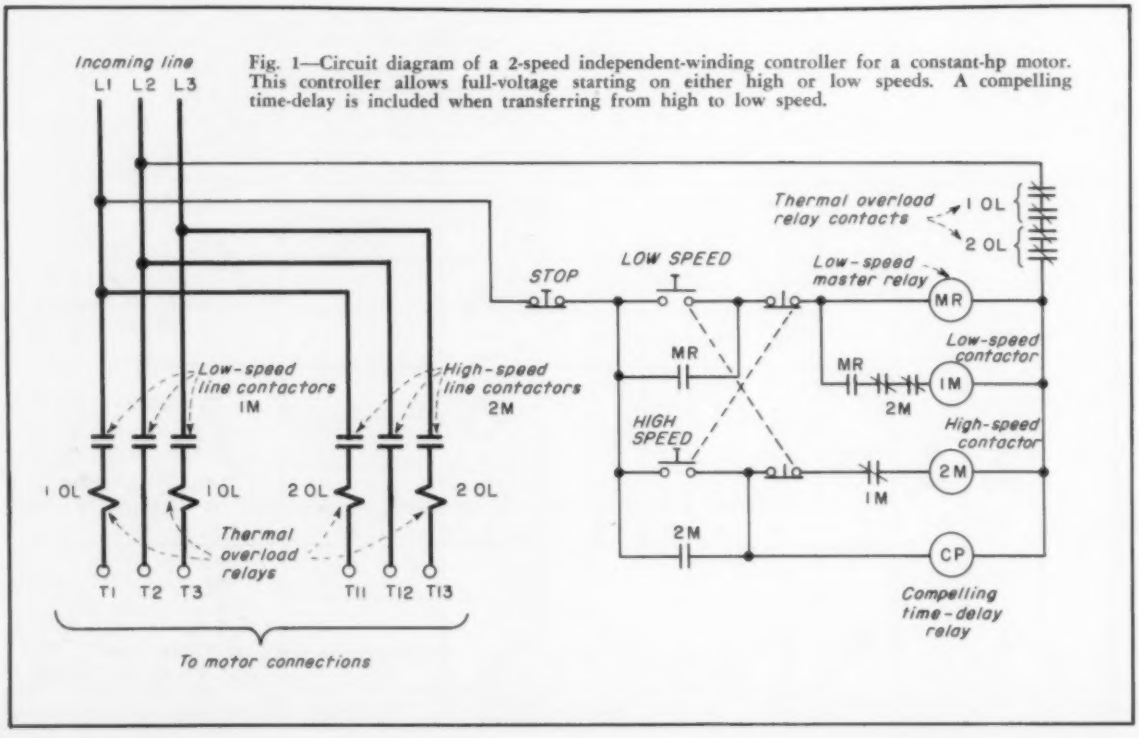
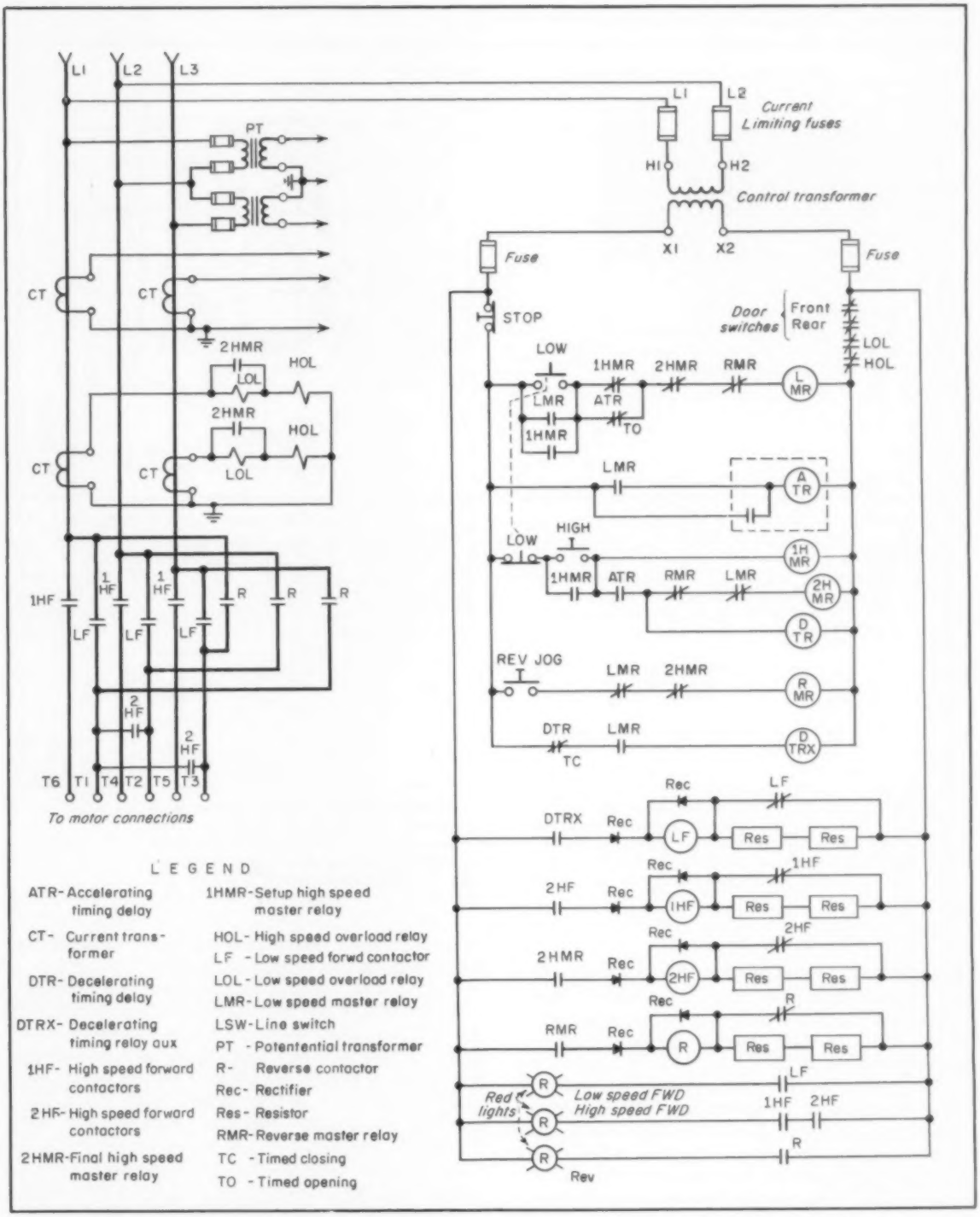


Fig. 1—Circuit diagram of a 2-speed independent-winding controller for a constant-hp motor. This controller allows full-voltage starting on either high or low speeds. A compelling time-delay is included when transferring from high to low speed.



LEGEND

ATR- Accelerating timing delay	1HMR- Setup high speed master relay
CT- Current transformer	HOL- High speed overload relay
DTR- Decelerating timing delay	LF - Low speed forwd contactor
DTRX- Decelerating timing relay aux	LOL - Low speed overload relay
1HF- High speed forward contactors	LMR- Low speed master relay
2HF- High speed forward contactors	LSW- Line switch
2HMR- Final high speed master relay	PT - Potentential transformer
	R- Reverse contactor
	Rec- Rectifier
	Res- Resistor
	RMR- Reverse master relay
	TC - Timed closing
	TO - Timed opening

Fig. 2—Circuit diagram for a 2300-volt 2-speed constant-torque motor controller which provides for low and high speed operation in the forward direction and low-speed jog operation in reverse. Starting currents are minimized by starting on low speed, and transfer currents are minimized by a compelling time delay occurring during transfer from high to low speed.

where experienced operating personnel may not be available, or where automatic operations are required during speed transfers.

The necessity for compelling functions on smaller controllers depends on the individual application. Automatic sequence and compelling functions are a requirement where the automatic control is necessary and where starting shocks to power systems or machinery must be minimized. The cost of adding sequence operation is considerably greater than that for the compelling operation.

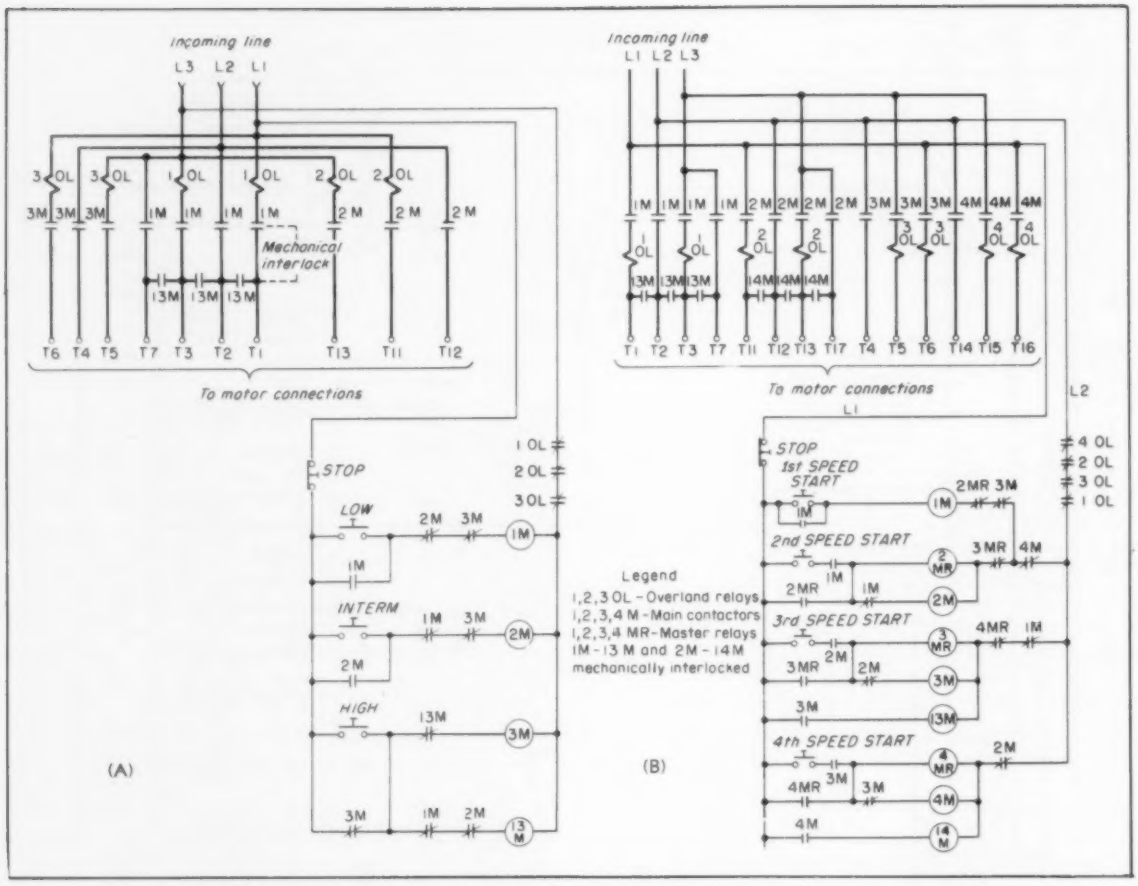


Fig. 3—Controllers for three- and four-speed constant-torque motors without sequencing or compelling time-delay provisions for transfer between speeds. Motors can be started any speed by operating the corresponding pushbutton. When transferring to a different speed the STOP button must first be depressed and the operator must wait a required time before actuating the pushbutton for the new speed. (A) is controller for a 3-speed motor and (B) is for a 4.

Controller Applications

Simplest multispeed motor controller is used for a two-speed independent-winding squirrel cage motor. Shown in Fig. 1, this circuit has two sets of main-line contactors, *M1* and *M2*. The control circuits are mechanically and electrically interlocked so that only one set of contactors can close at one time. With this controller, contactors *M1* operate the motor at low speed, contactors *M2* at high. The motor can be started directly on either speed and can be transferred from one speed to the other while in operation. However, when going from high to low speed, compelling relay *CP* automatically introduced the proper time delay between opening high-speed contactors *M2* and closing low-speed contactors *M1*.

Controllers for a two-speed single-winding motor, shown in Fig. 2, are more complicated than those for the independent-winding motors because of additional connections required. Mechanical and electrical interlocks are used in the control circuits to prevent accidental simultaneous closure of the low and high-speed contactors. This control circuit utilizes a timing relay to automatically transfer from the low to high-speed connection and also includes compelling transfer from high to low speed. Both starting and transfer currents are thus minimized.

The circuit of a three-speed constant-torque controller is shown in Fig. 3 (A) and that for a four-speed motor is shown in (*B*). These are of the non-compelling type and can be started at any speed by operating the corresponding pushbutton. If transfer to a different speed is desired, the *STOP* button must first be operated before the new speed can be obtained. This kind of controller is least complicated and expensive. However, to prevent accidental plugging when transferring from a higher to lower speed, the operator must wait until the motor has coasted to approximately the desired speed before operating that pushbutton.

EDITOR'S NOTE: This article is the first of a two-part series on multispeed motors and controls. The problem of applying these motors is more complicated than for single-speed motors, because factors such as speed, torque, and temperature rise, must be evaluated for each of the speeds at which the motor operates. The interrelationship of these factors for constant-hp, constant-torque, and variable-torque multispeed motors will be discussed in the forthcoming second article.

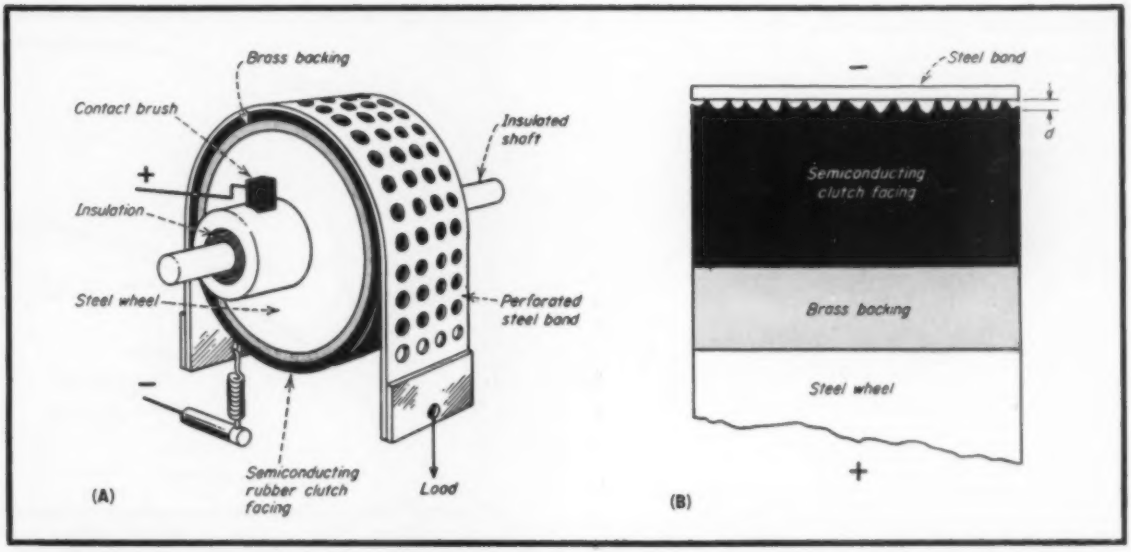


FIG. 1—Basic electrostatic clutch. Output member is a steel band which rides on large segment of rubber clutch facing which is made semiconducting by addition of carbon in original compounding. Rubber facing is molded to brass backing or plating on steel wheel which is insulated from the driving shaft. Application of voltage between steel band and wheel produces attractive force which draws band against facing and produces torque. (B) Magnified section of interface between clutch band and facing showing points of contact. Attractive force developed is proportional to area of clutch band next to facing and inversely proportional to square of distance d between. Distance d decreases as band and clutch surface are smoother; force is proportional to square of voltage for rough surface, increasing to higher power with increasing smoothness.

High-Speed Electrostatic Clutch

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International Business Machines
Endicott, N. Y.

Principles of operation; clutch construction and performance; three-clutch design example.

THE DEMAND FOR higher operating speeds of mechanical elements in electronic computers and data processing machines has resulted in development of a new electrostatic clutch which is inherently faster than electromagnetically operated devices. This new clutch is based on the Johnsen-Rahbeck effect in which an attractive force is developed between a conducting metal plate and a highly resistive, semi-conducting material by application of a voltage to the two elements.

Development of this principle has produced an electromechanical device which produces high mechanical forces from low levels of electrical control energy; operating currents and voltages are within the range of low and medium power vacuum tubes. The clutch is noninductive and has a low electrical time lag; its simple mechanical construction results in low mechanical inertia. The high torque-to-inertia ratio and low electrical time constant provide a response in the order of fractions of a millisecond for light mechanical loads and acceleration of shafts with moderate loads to high speeds in a few milliseconds.

Basic Operation

The basic components of the new electrostatic clutch are a clutch wheel and a steel band, as shown in Fig. 1(A). A semi-conducting clutch facing composed of a Buna B synthetic-rubber compound containing carbon is molded to a brass facing or plating on the wheel. The rubber is compounded to produce a volume resistivity of approximately 1 megohm per cm^3.

When a voltage is applied between the wheel and steel band, an electrostatic attracting force is developed which is directly proportional to the area and inversely proportional to the square of the distance between the metal band and clutch facing. This distance is represented by d in (B), which shows a magnified view of the interface between the metal band and the surface of the resistive material. Actual contact exists only at the points of surface roughness and even for surfaces lapped to optical

smoothness, the area of contact is only about 1 per cent. The smoother the surfaces the smaller d becomes, and the attractive force increases. As a result, the force developed is also proportional to the square of the voltage for rough surfaces and to the third or even fifth power of the voltage for surfaces of increasing smoothness.

Facing Material

The best material for the clutch facing is a rubber-base plastic made conductive by the addition of carbon particles. Electrical conductivity of the material is affected by the percentage of carbon used, the time the compound is milled, and the pressure applied when the compound is molded to the backing on the clutch wheel. Effect of these variations is shown in Fig. 2.

Lubrication

To prevent variations in clutch performance caused by wear, heat, and abrasion, lubrication is required. Ordinary hydrocarbon oils are unsatisfactory. Solid lubricants of Teflon and polyethylene can be used; a block of either material is pressed lightly against the clutch facing. However, continued use tends to build up a coating which requires a higher operating voltage at the end of a long run than at the beginning. For most applications the silicone oils and the Kel-F fluorocarbon oils and waxes are satisfactory. Minute quantities of oil are used. Too much oil reduces torque and increases residual drag at zero voltage; too little oil results in appreciable facing wear.

Clutch Bands

For a 2.5-in. diameter clutch, a tempered spring-steel band 0.003-in. thick was found to be best. Narrow bands develop more torque proportionally than wide bands because when the band is curved around the clutch wheel the outer surface stretches and the inner compresses, making better contact along the center than at the edges. Rows of holes are etched in the band to provide uniform transverse areas of contact with the clutch surface between the holes and to reduce zero-voltage drag. Narrow bands of $\frac{1}{8}$-in. or less function satisfactorily without holes.

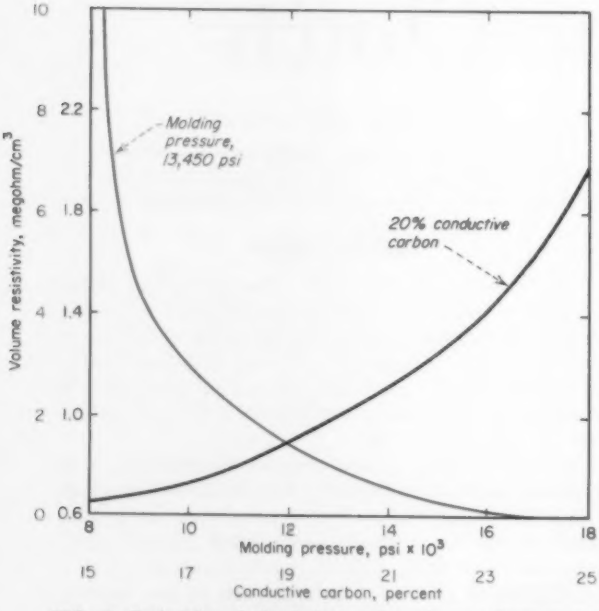


FIG. 2—Resistivity of clutch facing depends to a large extent on percentage of carbon mixed with rubber compound, as shown in curve in color, and to a lesser extent on pressure used when compound is molded to clutch wheel, shown in black.

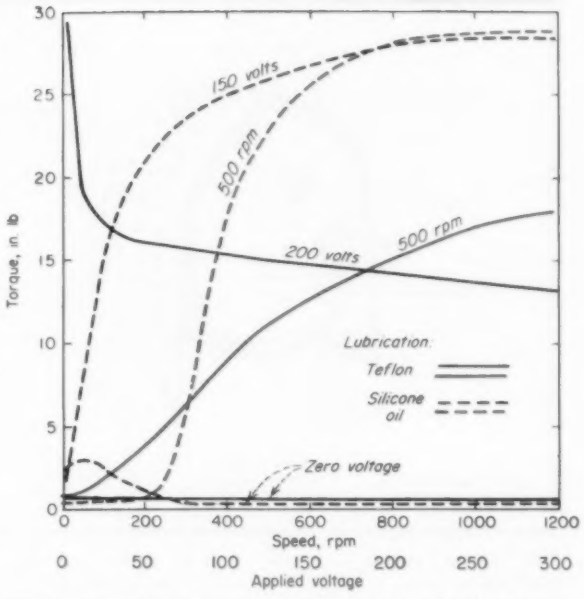


FIG. 3—Variation of torque: (a) with speed at a fixed voltage, (b) with voltage at a fixed speed, and (c) with solid or liquid lubricant. Curves shown are for test clutch 2.5-in. in dia with a $\frac{3}{4}$-in. wide band making contact with 180 deg of the clutch facing. This clutch was operated at 500 rpm drive shaft speed and intermittantly energized for 45 deg of each single rotation. Under these conditions it could dissipate about 30 watts without exceeding a 300 F band temperature.

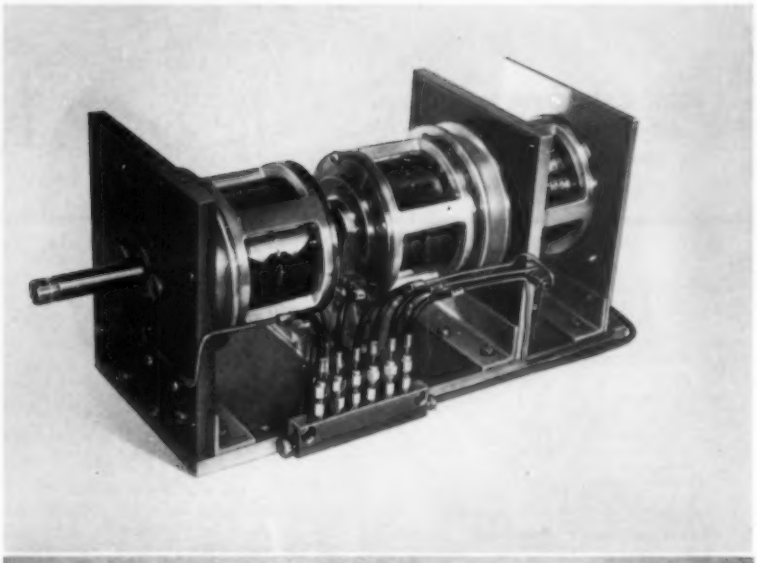
Performance

Torque developed is compared to the applied voltage and the speed of the driving shaft in Fig. 3. These data are for a 2.5-in. dia clutch using a $\frac{3}{4}$-in. band contacting the clutch facing over 180 deg of the wheel. Torque curves for both Teflon and silicone-oil lubrication also show zero-voltage or residual torque. With the clutch at rest, Teflon lubrication produces maximum torque while that of the oil-lubricated clutch approaches zero as the slip speed is reduced to zero. The liquid lubricated clutch behaves like a fluid drive system and requires some slip to develop torque.

The electrical response time varies with clutch resistance, and is a function of the actual contact area and the capacitance formed by those areas of the metal band and the facing which are not in intimate contact. Resistance values of the test clutches were adjusted so that with 180 deg of the wheel in contact with the band current flow at 150 volts was about 10 milliamperes.

These clutches operate over a wide variation in resistance; for the above values, actuating time from the

(A)



(B)

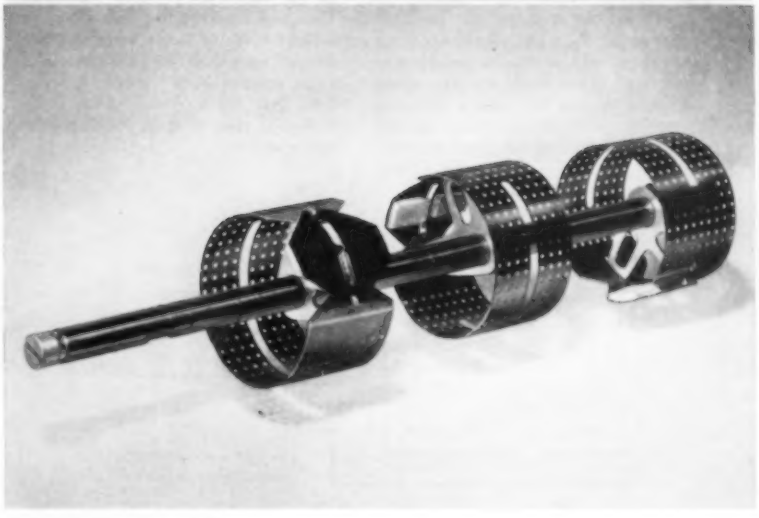


FIG. 4—(A) Assembly of a three-clutch unit. The clutch at the far right serves as a brake. V-belts are used to drive the other two clutches at high or low speed in either direction. Pipes are for silicone oil lubricant of one drop of oil per clutch wheel per hour. (B) Driving shaft and clutch band subassembly with inertia of only 0.0004 in.-lb-sec^2. These bands make contact for 270 deg of clutch wheel and provide from 80 to 100 in. lb of torque.

application of voltage to full developed torque is about 150 microsec. Clutch bands about $\frac{1}{8}$ in. wide will move light latches approx. 0.040 in. in 500 to 700 microsec.

Application Example

A high-speed electrostatic clutch assembly is shown in Fig. 4(A); three clutches are mounted on one shaft and arranged so that one acts as a brake and the other two are used either for high and low forward speeds or for forward and reverse. The output shaft is $\frac{1}{2}$-in. in dia and 13-in. long. Including the shaft, total inertia of the triple clutch unit is 0.0004 in-lb-sec^2.

In (B) the three bands used in the assembly are shown. The bands are wrapped around the clutch wheels for an angle of 270 deg. With two wheels the size described previously, more than double the torque shown on the curves in Fig. 2 is obtained because of the additional surface covered by the band. From 80 to 100 in. lbs of torque is possible. The clutches run cool under high speed and high work-rate conditions because of good heat dissipation from the bands.

For lubrication a Bijur oil pump supplies about one drop of oil per clutch wheel per hour inside the wheel. With an operating voltage of 150, a clutch current of 30 ma, and a load inertia of 0.00037 in.-lb-sec^2, the output shaft can be accelerated to full speed (1600 rpm) or can be stopped from full rpm within 3 millisec.

The clutch has been operated at speeds up to 2500 rpm and the shaft reversed without using the brake. Under these conditions the slip speed is equivalent to a speed of 5000 rpm. The accelerating and decelerating tests were made using a gear attached to the shaft and recording the impulses generated by the teeth passing the poles of a permanent-magnet pickup. The output voltage of the pickup was applied to an oscilloscope. Because the angular gear tooth spacing was known an accelerating curve was plotted from the oscilloscope tracing, showing angular rotation with time.

KIRK CARLSTEN, Chief Engineer
and KARSTEN HELLEBUST
Metron Instrument Company

12 Ways of

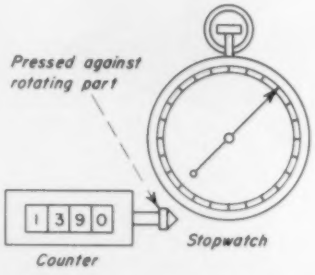


Fig. 1—Simple counter and separate stop watch: Requires dexterity since counter is held with one hand—stop watch with other hand. Average speed measured during one minute interval by noting the counter readings at beginning and end of the time interval.

Fig. 2—Combination counter and stop watch: Counter starts when button is pressed and then watch automatically stops counter hand at end of a given time (say six seconds). Dial is calibrated to read in rpm. Measures average speed.

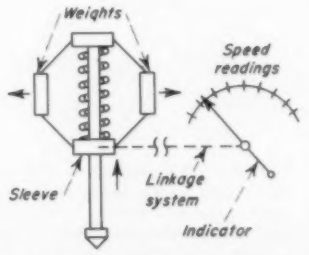


Fig. 3—Centrifugal tachometers: Centrifugal governor type mechanisms with weights which move outwardly from shaft as speed increases causing sleeve to move up. Sleeve through linkage moves indicator pointer in proportion to speed. Care must be taken to avoid overspeeding.

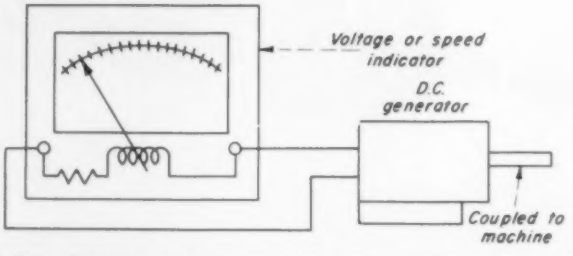


Fig. 4—D.C. Generator tachometers: D.C. voltage generated in proportion to speed and displayed on D.C. indicator or recorder. System does not use gearing and is usually limited to 150-2000 rpm at full scale. Generator matched with a particular indicator because voltage not exactly linear with speed.

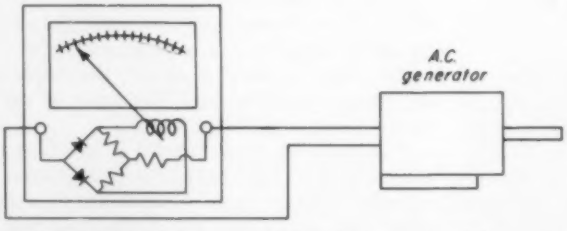


Fig. 5—A.C. Generator tachometers: A.C. voltage generated in proportion to speed and displayed on an A.C. indicator. System does not use gearing. Usually limited to full scale readings of 500 rpm minimum and 5000 rpm maximum. Not as accurate as D.C. systems, but covers wider speed range and does not require brushes.

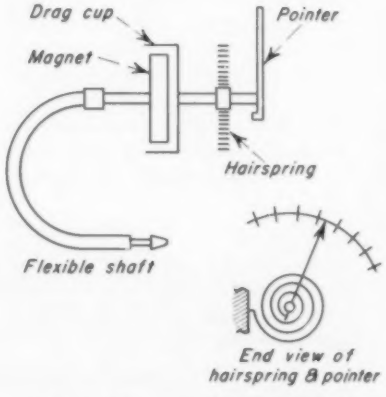


Fig. 6—Drag cup tachometers: Flexible shaft drives small permanent magnet in drag cup. Motion of magnet sets up eddy currents in wall of drag cup. Resulting rotary force causes drag cup to follow. Hair spring balanced to produce a pointer deflection proportional to speed. System simple and inexpensive, but with limited accuracy and speed range.

Measuring Speed

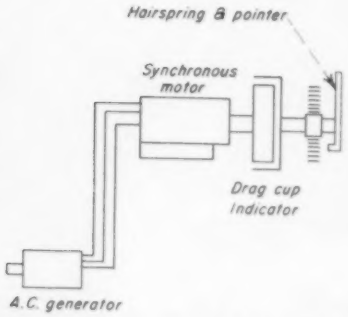


Fig. 7—Drag cup indicator driven by synchronous motor whose speed in controlled by remote A.C. generator. Synchronous motor drives small permanent magnet in drag cup similar to arrangement shown in Fig. 6. System expensive but without need for long and cumbersome flexible shafting.

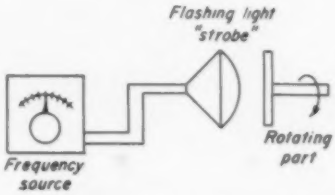


Fig. 8—Stroboscopic tachometers: Very fast flashing light used to view rotating part. Frequency of flashing adjusted until rotating part appears to stand still. Frequency reading corresponds to rpm of rotating part. Requires no accessible shaft and absorbs no power from rotating part. However, system requires constant adjustment if speed changes.

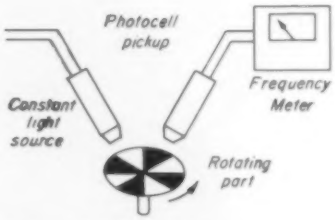


Fig. 9—Photo electric tachometers: Constant light source focused to shine on rotating disc; light reflects into photocell pickup. Intensity of light modulated by dark and light spots on rotating part. Frequency of modulations proportional to rotating speed and measured by frequency meter. Speeds up to 3,000,000 rpm can be measured but expensive equipment required.

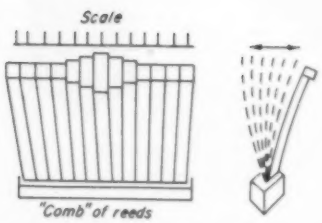


Fig. 10—Vibrating reed tachometers: "Comb" made up of a set of accurately tuned steel reeds: Comb held against any part of rotating machine, such as against case of motor. Vibration of machine vibrates only reeds "in tune" with machine's frequency. This speed, or frequency, read directly on a scale above the comb. Requires no access to a rotating shaft. Range is from 800 to 12,500 rpm with an accuracy within 50 rpm for individual reeds when new.

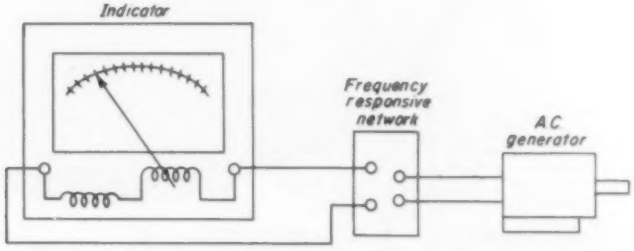


Fig. 11—A.C. frequency responsive tachometers: Similar to A.C. generator tachometers but measures generated frequency (not voltage). Range: 500 to 80,000 rpm with good accuracy. Expensive.

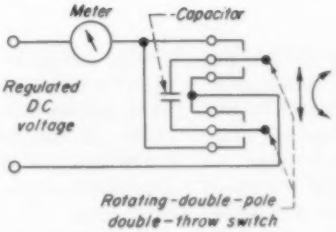


Fig. 12—Commutated capacitor tachometers: Rotating double pole, double throw switch charges and discharges capacitor. Resulting average D.C. current linear with speed. Current indicated on a D.C. microammeter as rpm. System very accurate. Linearity allows multiple range indicators and rotating switches are interchangeable.

J. W. EDGEMOND, JR.
Chief Engineer
Magna Power Tool Corporation

Unusual arrangements of epicyclic gear trains for control, counting and other light-duty high-reduction mechanisms.

Epicyclic Gears for

MANY VARIATIONS in epicyclic gear systems are possible, depending only on the designer's skill and imagination. Most of the known variations have been successfully used in one application or another but little use has been made of the two-gear epicyclic system to control mechanisms.

Loads in control mechanisms usually rotate at low speeds or over limited displacements, and epicyclic gear mechanisms are particularly suited to this field because of the following characteristics:

Irreversibility of epicyclic gearing is high in comparison with other systems such as worm gearing or screw and nut systems. This factor is important in hoists, lifting and tilting mechanisms, and other devices which operate against a continuous force such as gravity, wind or water loads, springs or stored energy devices.

For example, in the design of a tilt arbor saw (Fig. 1), use of epicyclic gearing prevents roll-back resulting from the unbalanced weight of the saw mechanism and motor when tilted. This gear system also permits use of a through shaft so that a single control knob can be used both for raising the saw blade as well as tilting it from 90 to 45 degrees.

Large ratio reductions are possible with only two gears. Most designers are familiar with the basic three-gear

Fig. 1—Use of epicyclic gearing in the tilting mechanism of a *Magna* table saw prevented a tendency of the motor when tilted to roll back the mechanism. Simplicity of the gearing also permitted one knob to control both lifting and tilting functions.

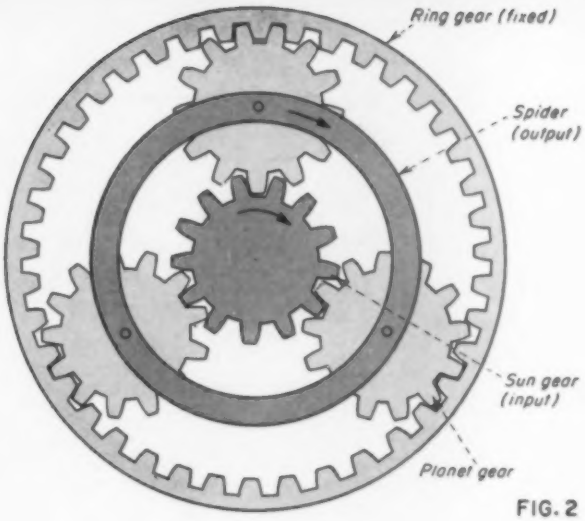


FIG. 2

Fig. 2—Basic epicyclic (planetary) system for speed reduction composed of sun, planet and ring gears. Input is to the sun gear; output is tapered off the spider. Three planet gears are shown although only one required.

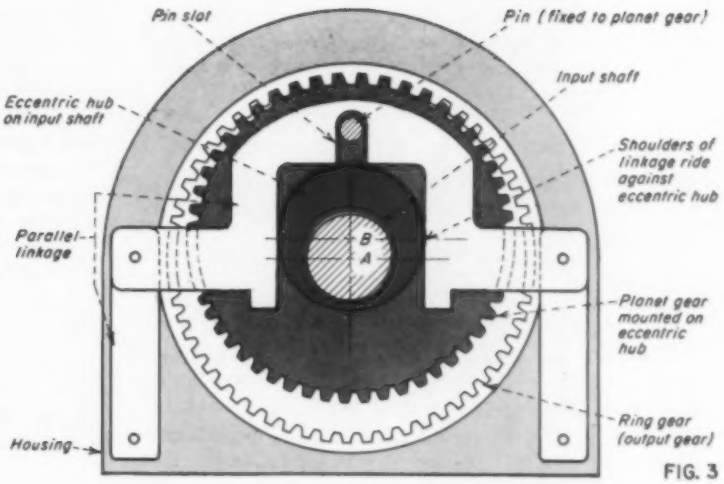


FIG. 3

Fig. 3—Epicyclic gear system with only two gears; ring and planet. Sun gear is replaced by eccentric shoulder and pin. Parallel linkage keeps pin slot vertical.

Control Mechanisms

epicyclic system composed of ring gear, planet gear and sun gear (Fig. 2). Input is to the sun gear when speed reduction is desired; the ring gear is fixed and output is tapped from the planet gear spider which drives a shaft in line with input shaft. Speed reduction is determined by:

$$N_o = N_i \frac{(d)}{(d + D)} \qquad (1)$$

where d = pitch dia of sun gear; D = pitch dia of ring gear; N_i = rpm of sun gear (input); N_o = rpm of spider (output).

For the system shown in Fig. 2, where the sun gear is approximately one-third of the ring gear in dia, speed reduction is equal to

$$N_o = N_i \frac{(D/3)}{(D/3) + D} = \tfrac{1}{4} N_i$$

However, a much greater speed reduction can be obtained by the two-gear epicyclic system illustrated in Fig. 3. With this arrangement the planet gear can be made almost as large as the ring gear. An input shaft with an eccentric hub replaces the sun gear. Point *A* is the center of the input shaft and point *B* the center of both the eccentric hub and the planet gear. The planet gear

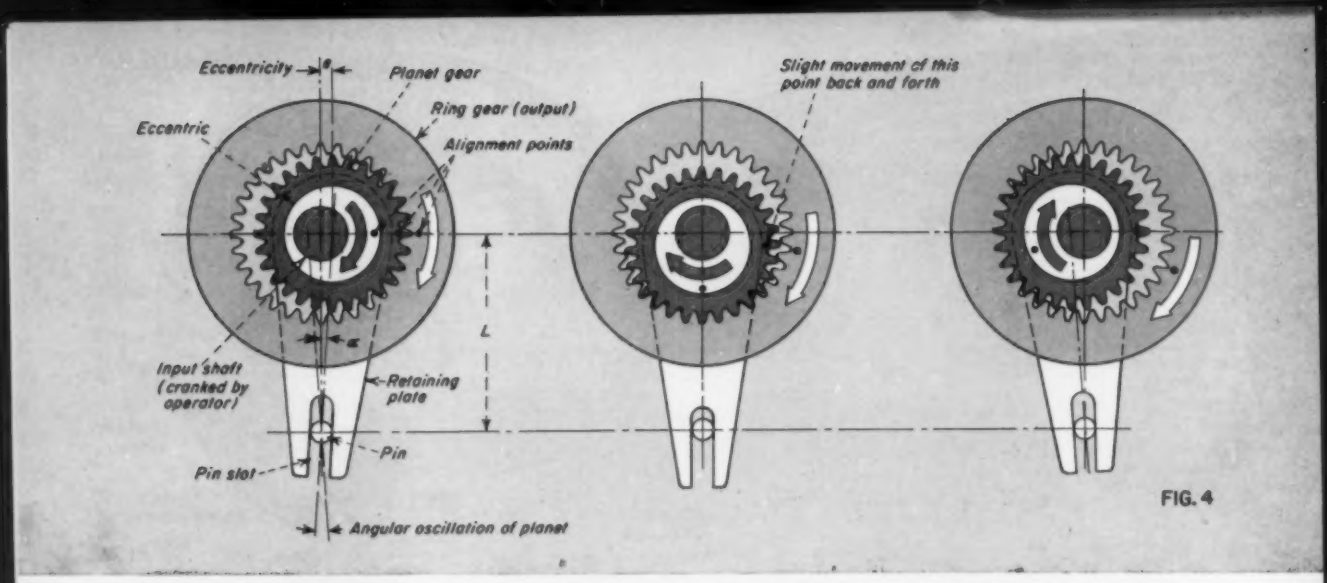


Fig. 4—Two-gear epicyclic system used in the tilting mechanism of the table saw in Fig. 1. The gear system is a simplified version of the one shown in Fig. 3, but since the pin slot is not kept vertical, the output motion of the ring gear contains slight pulsations. Note the changes in position of the alignment points.

rides on the eccentric hub but is prevented from rotating about its own axis by the pin. Function of the parallel linkage is to keep the pin slot always parallel.

Since the center of the planet gear follows the motion of the eccentric but is prevented from rotating around point *B* the ring gear will be driven with a constant angular velocity equal to:

$$N_o = N_i\left(\frac{D-d}{D}\right) \qquad (2)$$

where N_i = rpm of input shaft, N_o = rpm of output ring gear and diameters D and d represent the ring and planet gear, respectively.

For the system in Fig. 3 where $d = \frac{7}{8}D$, speed reduction is equal to $N_o = \frac{1}{8}N_i$

Applications of the Two-gear System

Many low-cost applications are possible by using simplified versions of the two-gear system shown in Fig. 3. Since control mechanisms seldom operate at both high loads and high speeds (in fact many control mechanisms rotate over limited angular displacements only) the efficiency and wearing qualities of the gear system is of secondary importance. Gears may be mass produced by production techniques such as die casting, stamping and powdered metallurgy.

Fig. 4 illustrates the principle of the two-gear epicyclic system applied to the tilting mechanism of the table saw in Fig. 1. The 32-tooth ring gear is the output of the system and the 28-tooth planet gear is mounted on an eccentric which is part of the crank shaft turned by the operator. The planet gear is not pinned to the eccentric but it is locked to a connecting plate that rides in a pin.

Cranking of the shaft causes the planet to scan the ring gear. Since the planet cannot rotate because of the retaining plate, the ring gear will be rotated by only the difference between numbers of teeth; or four teeth for each input revolution. Ratio of the system becomes:

$$N_o = N_i\left(\frac{32-28}{32}\right) = \frac{1}{8}N_i$$

Although the use of a retaining plate in place of the parallel linkage of Fig. 3 greatly simplifies construction, the pin slot is not kept vertical. This results in slight pulsations in the angular motion of the ring gear.

Fig. 5 shows an application of the same ring and planet system to a clock mechanism requiring a ratio of 12 to 1 between the hour and minute hands. In this case, the minute hand is connected directly to the eccentric which is the input to the mechanism, and the axis gear is the output connected to the hour hand. For each revolution of the minute hand, the 11-tooth planet would scan 12-tooth ring gear of the hour hand and gain one tooth or:

$$N_o = N_i\left(\frac{12-11}{12}\right) = N_i\,\frac{1}{12}$$

or $N_o = 1$ and $N_i = 12$

This arrangement can be produced inexpensively of die cast, stamped or molded gearing and is easily adaptable to digital counters in single or compound arrangement. In these counters the ring and planet have a ratio of 10/9 and the output of the first system drives the next eccentric, and so on as shown in Fig. 6:

$$\frac{10-9}{10} = \frac{1}{10}$$

Harmonic Pulsations in Output

One of the characteristics of the system described in Figs. 4 to 6 is that the output speed pulsates harmonically. This is caused by the simplified methods used to lock the planet gear. However, the pulsating characteristics are used to advantage in the design of clock and counter systems to avoid partial movement of the hour hand or counter dial, which would result in some confusion in reading. The retaining plate imparts an angular motion to the planet gear which is a function of the eccentricity e and the distance between the center lines of the eccentric and pin *L*, as defined in Fig. 4. Extending the distance to the pin will reduce angle α and the amplitude of the harmonic pulsations in the output. Therefore it is desirable in the counting mechanism to have distance *L* as short as possible to give maximum amplitude to the harmonic pulsations of planet movement. This would cause the

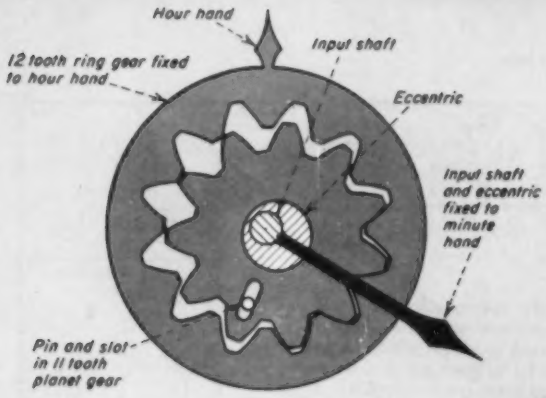

Hour hand
Input shaft
12 tooth ring gear fixed to hour hand
Eccentric
Input shaft and eccentric fixed to minute hand
Pin and slot in 11 tooth planet gear

Fig. 5—Clock mechanism using a two-gear epicyclic system to obtain a 12 to 1 ratio between minute and hour hand.

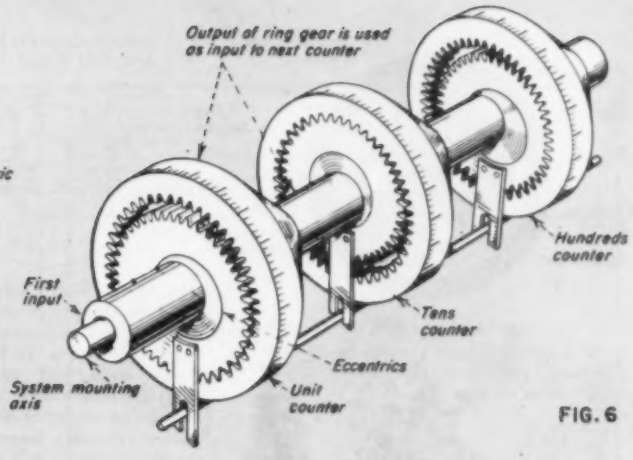


Fig. 6—Counters using same system as in clock mechanism to obtain a 10/1 ratio. Output of first counter drives input of second counter and so on.

driven dial to remain nearly motionless during a large part of the planet travel and then move rapidly to the next successive position.

In some applications, the harmonic pulsations can be undesirable; for example, in the case of torque multiplying mechanisms the ratio would be non-linear and non-existent during portions of its rotation. System in Fig. 3 completely eliminates pulsations. A slightly more complex system, shown in Fig. 7, provides a positive "lock" to the rotation of the planet gear, and also completely eliminates pulsations. The eccentric is replaced by a spur pinion which in turn rotates two spur-driven crank shafts on which the planet is mounted. Axes of the crank shafts are fixed to the housing which is not shown. Additional speed reduction is also possible since a simple first-stage speed reduction is obtained between the input and gear-driven crank shafts.

For example, a hoist mechanism can be devised with 4 to 1 primary reduction and an epicyclic reduction of 50/1 by having a ring gear and planet ratio of 100/98. This would give an overall hoist ratio of 200 to 1.

Tooth Interference

As the pitch diameter ratio between ring and planet gears approach 1/1 special attention must be given to the design of the gear teeth to avoid tooth interference. This requires pressure angles of 30 deg and upward as well as adjusted addendums and dedendums. In addition, rolling action between the teeth is virtually eliminated resulting in a high degree of sliding friction. Friction developed becomes predominate and if a low overall system efficiency is of primary concern, maximum attention should be given to application of gear and bearing materials with the lowest co-efficient of friction.

Although close ratios between ring and planet gears prevent proper involute action, they do permit the use of cheaper low-cost, low-stress materials for gear construction because a greater number of teeth share the load. Also, the high friction which results in loss of system efficiency provides the irreversibility required in mechanism applications similar to the tilt gear of the MAGNA saw which must not feedback the unbalanced load of the saw mechanism and motor. The actual ratios, materials, and epicycle system used in the saw mechanism were based on a careful analysis of the desired input load to tilt the saw against the unbalanced force of gravity, component cost, and system irreversibility.

Systems Using Only External Gears

Epicyclic gear systems using only external spur gears have much higher efficiency although they are generally more complex in construction. The mechanism shown in Fig. 8(A) is known as Watt's gear, or more commonly as a "sun and planet" mechanism. When James Watt perfected his steam engine, he was prevented from using the crank and connecting rod because of earlier patents and was forced to adapt the "sun and planet" principle. In his application, the sun, or axis gear, was keyed to the output shaft of the engine, and the connecting rod from the steam cylinder was fixed to the planet gear to prevent the planet from rotating relative to the system. The connecting rod acts in this case exactly as the locking plate in Fig. 4. A circular groove that is stationary keeps the two gears in mesh.

In operation, the action of the steam cylinder causes the planet to revolve around the system axis as a crank. Since the planet is not fixed to the main shaft, the patents preventing the use of a crank were circumvented. Planet and sun are of the same size, and because the planet is prevented from rotating relative to the system axis by the connecting rod, it makes one clockwise revolution about its own axis for each counterclockwise revolution around the sun, as illustrated in Fig. 8(B).

Since the planet makes one revolution around both axes, the output shaft or sun gear will make two revolutions. If sun and planet are of different diameters, the output would be affected as follows:

$$\frac{N_p}{N_s} = 1 + \frac{D_p}{D_s} \qquad (3)$$

where N_p = revolutions of the planet around the sun (or the number of piston strokes); N_s = revolutions of the

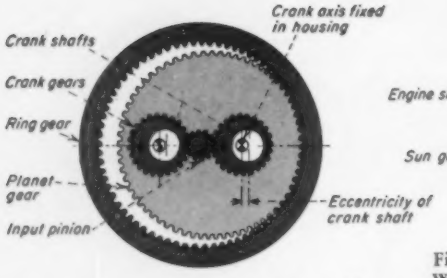


Fig. 7—Using double crank gears with two eccentric shafts to eliminate the harmonic pulsations that exist in the mechanisms of Figs. 4 to 6.

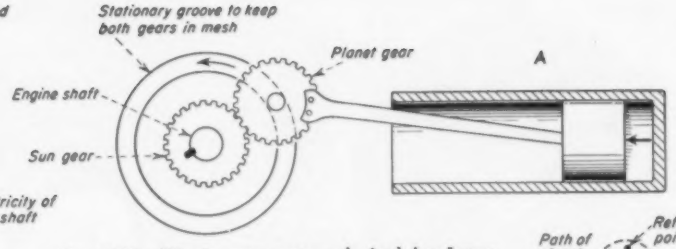
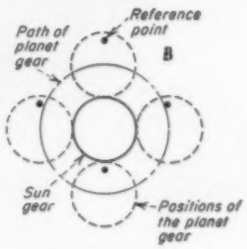


Fig. 8(A)—Watt's gear system devised by James Watt to circumvent patents which prevented him from using a slider-crank mechanism for his steam engine. System is similar to that of Fig. 4 with the exception that only external gears are used. Fig. 8(B) illustrates how the planet gear can be considered as revolving around its own axis in addition to revolving around the sun, even though it is fixed with respect to a vertical plane.



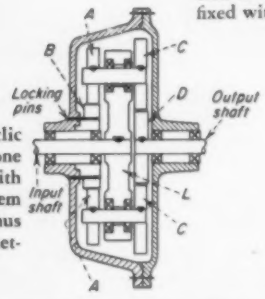


Fig. 10—Double epicyclic system, similar to the one shown in Fig. 9, but with an opposing planetary system to prevent unbalance. Thus there are two sets of planetary gears A and C.

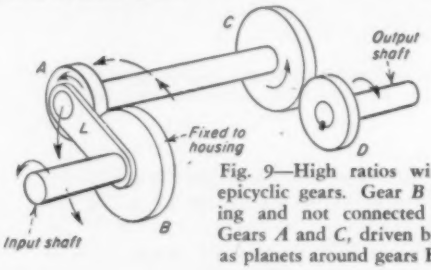


Fig. 9—High ratios with only external epicyclic gears. Gear *B* is fixed to housing and not connected to input shaft. Gears *A* and *C*, driven by link L, revolve as planets around gears B and D.

sun or engine shaft; D_p = pitch dia (or number of teeth) of planet; D_s = pitch dia (or number of teeth of sun).

If $D_p = D_s$ as in the Watt gear system then for each piston stroke, the engine shaft will revolve: 1 + 1 = 2 rev.

To obtain high gear ratios and concentric input and output shafts, and also to simplify the construction, it is more common to use the compound arrangement of external gear epicyclic system known as a reverted or folded-back epicyclic mechanism, illustrated in Fig. 9. Two axis gears and two planet gears are used in which the first axis gear *B* is fixed or locked, and the input to the system is through the crank *L*. The first or primary planet gear *A* is keyed to planet gear *C*, and both are free to rotate on their own axis. Output is through gear *D* and output shaft. In operation, the first planet gear *A* is rotated around its own axis on the crank by the action of the crank input *L*. Its rotation is expressed relative to one revolution of the crank as: 1 = B/A.

For example, if planet A has 20 teeth and sun gear *B* has 30 teeth, then for each revolution of the crank, planet *A* will rotate around its own axis 1½ revolutions. Rotation will be in the same direction as the crank link.

Gear C, keyed to planet *A* and meshed with output gear *D*, also has the same ratio to the link rotation, so that *D* will revolve at a ratio of: (B/A)(C/D).

However, the planet gears have also made one revolution relative to the system axis and the ratio between input N_i to output N_o will be equal to:

$$\frac{N_o}{N_i} = 1 - \frac{BC}{AD} \qquad (4)$$

It is this insignificant value 1 in the equation that takes the mechanism out of the simple gear reduction class and permits the high ratios possible. Where the factor BC/AD is less than 1, the output rotation of the system will be in the same direction as the input; where greater, the output rotation will be opposite.

As an example, suppose a speed reduction of a 100/1 ratio is desired with output rotation the same direction as the input. Eq (4) would become:

$$\frac{BC}{AD} = 1 - \frac{1}{100} = \frac{99}{100}$$

Therefore: $BC = 99$, $AD = 100$

Simplest arrangement is:

$$\left(\frac{9}{10}\right)\left(\frac{11}{10}\right) = \frac{99}{100}$$

Problem remaining is how to have a ratio of 9/10 and 11/10 on the same gear centers since there are only two axes in the system. In other words $9 + 10 \neq 11 + 10$. If the same diametral pitch for both pairs of gears is desired, then the minimum actual teeth for this mechanism would be $(9 + 10) \times 11$ and 10 for the *C* and *D* gears respectively, and $(10 + 11) \times 9$ and 10 for *B* and A, or

$$\left(\frac{189}{210}\right)\left(\frac{209}{190}\right) = \frac{99}{100}$$

This, of course, requires large gears or extremely fine diametral pitches. The obvious solution is to adjust the diametral pitches of the primary and secondary trains to suit the same center distance.

Where the input speed is very high, it is necessary to either counter-balance the weight of planet assemblies or install a second planetary system opposite the first by extending the crank link as shown in Fig. 10. This also reduces the tooth load and resulting gear stresses. Because there are only two concentric input and output bearing assemblies in the housing and only four of the gears are radially loaded, cost of the gear system is low in comparison to the high-ratio speed reduction that can be obtained.

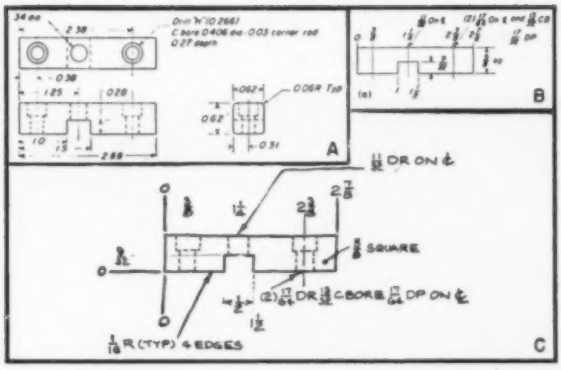


Fig. 1—Three drafting conventions are compared for ease of interpretation and drawing speed. (A) Conventional practice uses three views standard dimensioning and notation. (B) Views reduced to one, dimension lines and arrows omitted, centerline notations and abbreviations used. (C) Freehand sketch includes hidden lines, ordinate dimensioning.

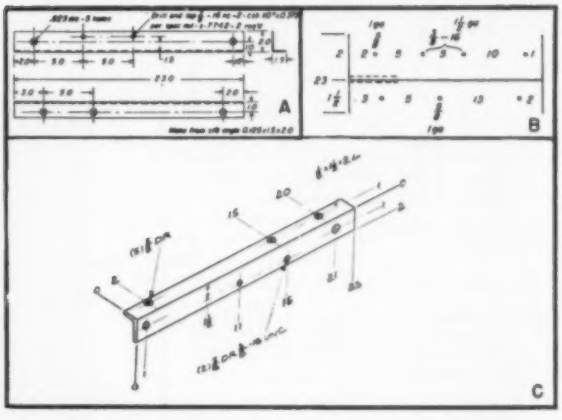


Fig. 2—Similar conventions on L-shaped section in (A) conventional practice, (B) extreme simplification and (C) freehand sketch plus ordinate dimensioning.

Functional Drafting... Another Viewpoint

Similar objectives but with a different approach characterize these suggestions. Hidden lines are included but freehand drawing and ordinate dimensioning are emphasized.

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THE VALUE ENGINEERING GROUP, U.S. Navy, Bureau of Ships, has assigned a group at the San Francisco Naval Shipyard the task of investigating the simplification of engineering practices. This paper is an outline of the drafting phase of this program.

In the development of a common sense drafting room system the cooperation and advise of the shop is mandatory. As the largest user of drawings the shop deserves first consideration in all simplification methods. The dimensioning system should be functional and suit shop methods of measuring and manufacture. No pencil work should be required in the shop in order to use the drawing. The drawing should be devoid of superfluous frills or views that add nothing to clarity or completeness.

Some of these comments may infer adding to the drawing and not simplifying. Actually, by adding clarifying information, employing functional standards and conventions to the fullest extent and using minimum views required for complete clarity, two purposes are accomplished; that of furnishing more necessary information and taking less time and space to accomplish this end. With this basic philosophy in mind a sensible drafting room system may be formulated.

In setting up a functional drafting system it has been found that, in general, the shops are very co-operative, and when trial drawings have been evaluated little trouble is encountered in understanding. Most shops care little if the drawing is freehand, if only one view is shown, or if the drawing is to scale (as long as proportion is about right). They are interested in having all the necessary information for manufacture or assembly shown in clearly understandable fashion. In the drafting room however, adoption of new methods often becomes an emotional human problem.

The cardinal points of functional drafting can be summed up as freehand drawing, simplified delineation, and functional dimensioning.

Freehand Drawing

The tools of drafting do not constitute the subject of drafting, and may often be dispensed with to great advantage. (This is not to advocate their elimination for the design layout, of course.) Freehand drawing is applicable to all phases of engineering drawing in various degrees. In mechanical detailing it can be employed almost exclusively with probably lesser application in other fields. Complexity of detail need be no problem and most competent draftsmen can learn to do neat and readable freehand work.

Freehand drafting can be divided into the following types: freehand tracing from assemblies; scaled freehand using grid underlays or printed grid paper with non-actinic lines; freehand using no scale or guide. Freehand drafting does not compromise clarity and, of course, is not license for sub-standard or sloppy work. It does, however, provide a time saving factor of 20 to 50 per cent.

Opinions expressed herein are those of the author and not necessarily those of the Navy Department.

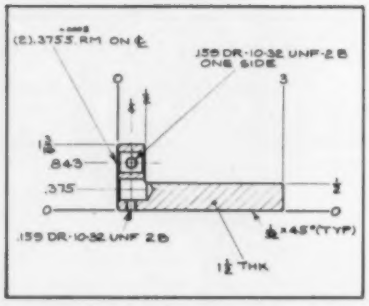


Fig. 3—More complex part showing use of crosshatch, conventional holes and ordinate dimensions. (From actual production drawing.)

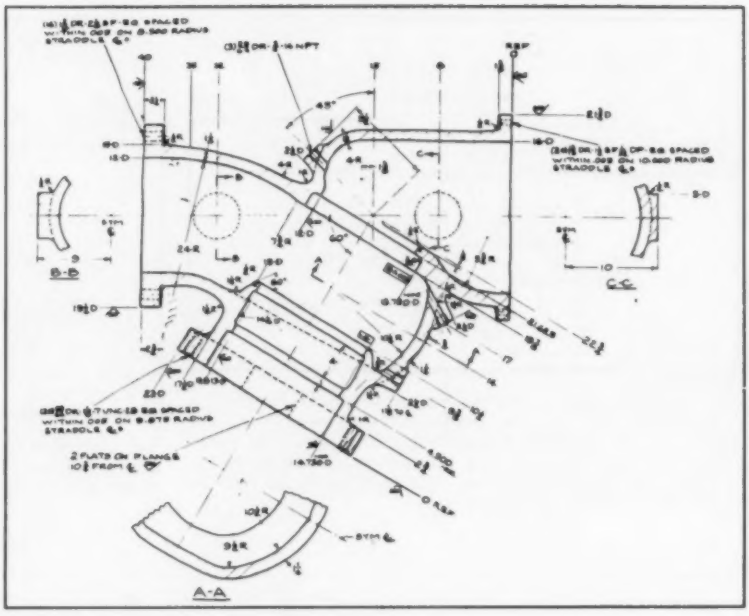


Fig. 4—Freehand traced valve casting with supplementary views as required for clarity. Ordinates start from bottom and right hand flanges.

Simplified Delineation

Reduction of a drawing to only essential views makes good sense. At the shop interpretation level it is generally agreed that the briefer the physical rendering of the picture, if all required information is indicated clearly, the better the drawing. Most important are the dimensions and how they are shown. Of the errors that do occasionally occur in manufacturing parts, the greatest majority are errors in size, not in shape.

In contrast to some opinions, however, it is felt that whatever views are shown should be complete, with all necessary holes and lines giving an undistorted picture of the part. The danger of over-simplification and consequent misunderstanding cannot be overemphasized.

Functional Dimensioning

No other single factor has more influence on the use of drawings than the dimensioning practice. It is not sufficient to have dimensions numerically correct. It is of equal importance to have dimensions placed so as to be of direct use without rearrangement or computation at the shop level. Included in the scope of this concept is ordinate dimensioning. Ordinate dimensioning is functional and logical for practical shop and drafting room use on many intricate parts, castings, and turned work, but it must be imployed correctly. Ordinate dimensioning, as shown in the illustrations, eliminates actual dimension lines and arrowheads. This is incidental to its use and does not sacrifice clarity.

Advantages of simplified delineation and ordinate dimentioning are:

1. Large scales without increase in format size.
2. Dimensions large and clear. Little or no crossing of dimension or leader lines.
3. Eliminates unnecessary views and lines.
4. Not limited to ordinate dimensioning.
5. Consistent with photo reduction methods without sacrificing readability.
6. Functional for shop measuring methods.

On the negative side, it has been found that probably better judgment must be exercised when using functional techniques and ordinate dimensioning since fewer rules and generalizations apply. Also, it has been found that thorough training in classical methods is an aid to functional drafting.

Sample Applications

Figs 1 and 2 use the same examples as used by H. H. Ash in his paper on Drafting Procedures (*Product Engineering*, August 1955), but rendered in the method felt to be functionally correct for this class of work. Fig. 3 shows a more complex detail using the minimum views and ordinate dimensioning. This type of drawing is acceptable and readable to the shop and is taken without change from an actual production drawing used at San Francisco Naval Shipyard.

Fig. 4 is a detail of a valve casting shown in simplified form and using ordinate dimensioning. Note the clear delineation and absence of frills. The original drawing of this part had three more views, a larger drawing format, and offered no greater clarity.

The soundness and practicability of functional drafting is being proven. Shop acceptance and response has been enthusiastic. Engineering Department adoption is only a matter of time and is urged on by the policy of shop trial and evaluation.

The ultimate aim of the Navy Group is to have drafting practices, and the use of standards and conventions consistent throughout all Naval activities. Actually, consistency depends on supervision and enforcement rather than the existence of a uniform drafting room manual. The rate of progress to date indicates that adoption of functional methods is a matter of a few years.

TECHNICAL NEWS

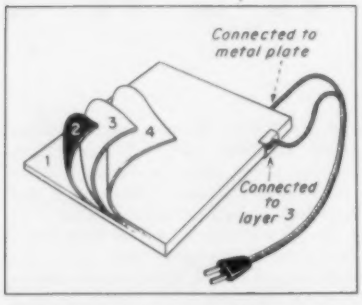
DR. E. F. LOWRY, Manager of Fluorescent Engineering, Lighting Div., Sylvania Electric Products, Inc., Salem, Mass., is shown with one of the developmental units. Because it uses enameling steel with a ceramic-phosphor coating, the lamp is not fragile, and its basic cost is lower than those using conducting glass. The steel sheets may be cut or stamped into any desired shape with as many holes, or slits as necessary. The lamp is then processed.

AFTER CUTTING, the lamp is processed by coatings and firings where the panelescent lamps receive the first coating of phosphor materials. At present, the lamps are available in green, blue and yellow.

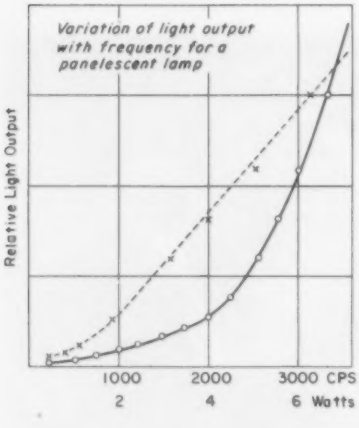
Panelescent Lamp Uses Phosphor-Ceramic on Steel

Sheet steel is replacing expensive conducting glass in Sylvania Electric's new Panelescent lamp, a new area light source which is expected to find extensive application as instrument panels, clock faces, radio panels, indicator lights and other markers. It operates without the usual filament, vacuum, or gas discharge. Scientifically, it can be classed as a luminous capacitor or condenser. Searching for a method to replace conducting glass as one of the elements of the panelscent lamp, Sylvania found that if a piece of enameling steel was coated with a mixture of phosphor and the proper ceramic frit, fired onto the steel and then sprayed while hot with a solution of a tin salt, a luminous capacitor was the result.

The steel used is 20 gage and at present in a maximum 7 x 14 in. size. The metal should be flat, and all holes should be punched into the sheet before any work is done on the sheet. The steel serves as one conductor, as well as providing the strength for the finished lamp. A layer of solid ceramic material similar to white porcelain is fired onto this base sheet. Following this is another layer of ceramic material in which is suspended the electroluminescent phosphor. These two layers serve as the dielectric. The light is emitted from the dielectric phosphor layer. A transparent electrically conducting layer is next applied to the dielectric phosphor coating. This layer corresponds to the other plate of the electrical condenser. One electrical connection is made to the metal; the other to the transparent electrically conductive layer. A final finish layer of transparent glass is applied over the



THE SIMPLIFIED STRUCTURE of the panelescent lamp: (1) metal plate, usually 20 gage, with a ceramic coating; (2) one or more ceramic and dielectric layers containing phosphor; (3) a transparent electrically conducting layer; (4) a transparent insulating finishing coating to protect the lamp from the effects of humidity, and other damage.



electrically conducting layer to protect the lamp from humidity, and to provide an insulating outer surface. Total thickness of all the coatings applied is less than 1/50 of an inch.

At present the panelescent lamps are available in green, blue and yellow. As there is no arc or glow discharge in the lamp, super imposed spectral lines such as are found in mercury vapor or fluorescent lamps are not found in the panelescent lamp. The color of the lamp is dependent almost exclusively on the phosphor used. As the frequency of the supply voltage is increased, there is a shift in color towards the blue end of the spectrum.

In terms of brightness the present panelescent lamp is usable economically only where illumination levels are low. At 120 v and 60 cycles a green panelescent light has a brightness of 0.1-0.3 foot lamberts; at 600 v and 60 cycles the brightness is upped to 2.5-3.5 foot lamberts. At 120 v and 400 cycles, a green panelescent light has a brightness of 0.4-1.0 foot lamberts; at 600 v it is increased to 7.0-15.0 foot lamberts. As a means of comparison, a white 400 watt fluorescent lamp has 1900 foot lamberts.

Operating life of the panelescent lamp is very long. Fundamentally, a condenser, the lamp will fail only when subjected to conditions which will cause a condenser to fail. Somewhat independent of the ambient temperature, raising the temperature from 80 to 100 F will increase the brightness by 2 to 3 per cent. With a further increase to 175 F, the brightness is decreased to about 90 per cent of initial. Reducing ambient temperature from 80 to 60 F will cause a decrease of 3 per cent. Further reduction to 32 F will see less than 10 per cent in light output.

Operation of the panelescent lamp at voltages above the design voltage will cause a breakdown or puncture of the dielectric. The puncture appears as a small spark, which leaves only a small black speck which tends to be self-sealing. Continued puncturing of the dielectric will reduce the light output below a satisfactory minimum.

To get the necessary red for aviation use with a complete cut off at 600 millimicrons, Sylvania made a blue panelescent lamp, then painted it with the proper fluorescent dye dissolved in a suitable plastic. The dye responds to the blue light emitted by the lamp and emits the required red light.

Congress to Study Patent System

The new Congress definitely will study this country's patent laws and the way that they are administered by the U. S. Patent Office and the courts. Congressmen taking on the job got some guidance recently from Dr. Vannevar Bush, who told them where to dircet the search for pitfalls and offered suggestions for improvements in the present patent system. Dr. Bush gave his views in a 30-page report, entitled "Some Proposals for Improving the Patent System," the first of about a score of reports to be prepared by outside experts for the Senate Judiciary Subcommittee on Patents, Trademarks and Copyrights.

The Subcommittee, headed by Senator Joseph C. O'Mahoney (D. Wyo.), will use the reports in hearings later this year which are aimed at producing new legislation to bring the patent laws—scarcely changed in over a century—into line with today's invention and industrial development setup.

Dr. Bush concedes that "recent tendencies" have largely undermined confidence in the patent system. Also, Bush is as impatient with those who would do away with the entire structure as he is with others who have too long been inclined to leave the system untouched. Dr. Bush suggests a number of specific corrective measures to simplify the complex patent law and practice to the needs of the inventor, business and consumers. His main proposals:

Too many patents are involved in litigation. To correct this, larger funds for staff and wide use of computer devices should be made available to help examiners in their search through document files to establish lack of prior art of an invention. Such mechanization should cover published technical and trade journal literature as well as previous patents. Bush says that this would lessen the possibility that already issued patents will be overthrown on the basis of previously unnoticed publications.

The Patent Office, before taking final action on a patent application, should provide an opportunity for others to oppose issuance by presenting overlooked facts on the proposed patent. This would require a published description of the invention before the patents is granted.

Congress should legislate more specific and restrictive criteria for determining what constitutes a new invention. It should limit patents to situations in which such protection is needed to bring a useful invention into production.

Special administrative tribunals

should be established in the Department of Commerce to rule on the scientific facts in litigated patents, and the determinations of these hearing boards should be binding on the courts. This would free jurists who generally lack scientific training to rule only on the legal issues.

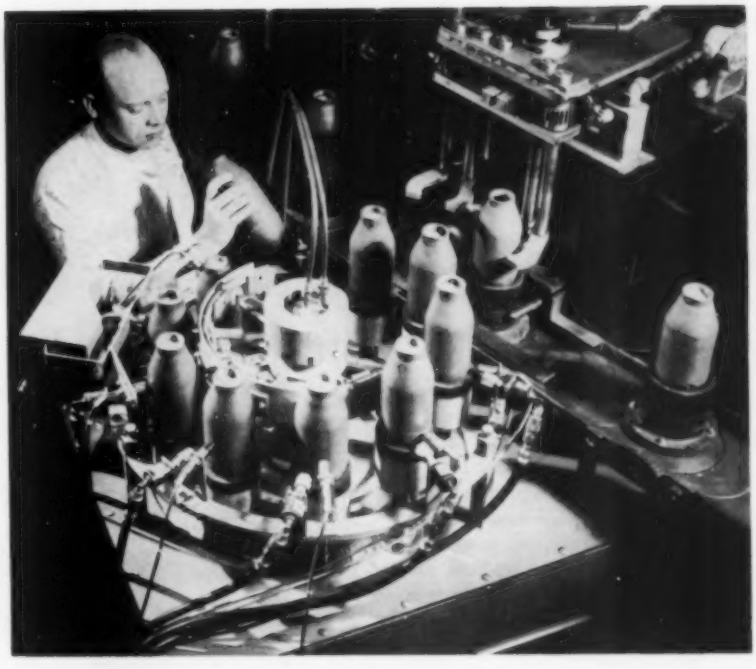
Compulsory licensing at a reasonable royality. This should be limited to cases: (1) where restrictive patent pools result in industry domination; (2) in situations where entry to an industry is denied through patent control perpetuated by improvement patents; (3) and in cases of antitrust violations; and (4) where there has been unreasonable patent suppression.

Dr. Bush feels that the Antitrust Laws are a "blunt bludgeon" for dealing with "the subtleties of the problem of patent licensing." He figures that licensing of all comers at small royalities may produce just the deadly inertia and lack of initiative in an industry which the patent system is supposed to forestall. Yet, "Destroying the patents by requiring free licensing may be even worse."

Bush cites the automobile manufacturing industry as a case in point in discussing the drawbacks to open patent pools. The auto makers' "unduly soft type of patent handling" is partly responsible for the industry's failure to measure up to American ideals, on radical technical advance, compared to European attainments.

The Bush report will be followed in a few weeks by two others—a review of the patent system in terms of its function and operation in today's economy, and an exhaustive compilation by the Patent Office analyzing ownership of patents issued since 1939. The Patent Office data, which includes an analysis of the patents issued to 176 large corporations, shows that corporations got 59 per cent of all patents during the 16-year period covered.

General Electric and its corporate affiliates heads the list with 10,757 patents. American Telephone & Telegraph Co., with 8539 was second. The next eight were: Radio Corp. of America (7894); Westinghouse Electric Corp. (7567); E. I. du Pont de Nemours & Co. (6338); Esso Standard Oil Co. (4899); General Motors Corp. (4041); Eastman Kodak Co. (3784); Bendix Aviation Corp. (3113); and American Cyanamid Co. (2872).



Automatic X-Ray Inspector Checks Rocket Explosive Charge

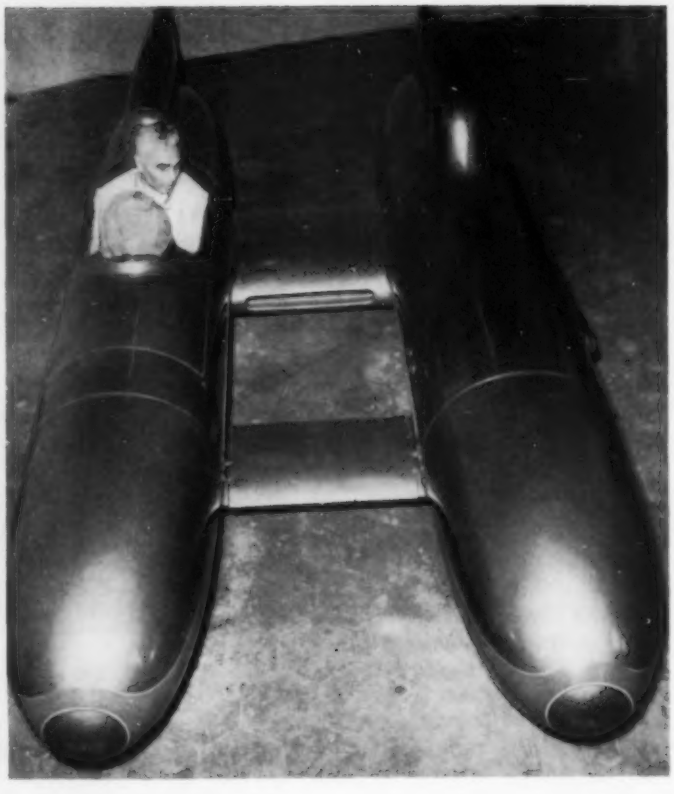
Now completing tests for the Army Ordnance Corps is this X-ray device which will automatically inspect the explosive charge in each artillery rocket and mark any that have defects as it comes off the production line. The device shown here was installed at the Cornhusker Ordnance Plant in Grand Island, Nebraska, to inspect 3.5 rockets. However, the principle of the machine can be adopted to future machines that will automatically inspect other types of ammunition, such as artillery shells, mortar shells, land mines, and grenades.

Since 1943, such ammunition inspection has been done mostly by X-ray photographs which are checked by X-ray technicians. The new setup reduces the human error by eliminating the use of X-ray film. It also requires fewer inspection personnel.

In operation, rockets are transported by conveyor to a circular inspection platform (see photo), in the center of which is a conventional 250,000 v X-ray machine which sends X-ray beams to six inspection stations located around the rim of the platform. At each inspection station is a cadmium selenide crystal which is sensitive to X-rays and is the eye of automatic inspector.

Each rocket moves around the inspection platform to each station, rotating as it goes and moving up and down. At each station, it receives the X-ray beam in a different part of the rocket. If the explosive charge is sound and uniform, it passes only the normal amount of X-ray beam. If there are flaws in the explosive charge, the X-ray beam passing through the rocket and striking the cadmium selenide crystal will increase. This increase excites the crystal, and it releases an electrical current that feeds into a digital computer information on just how much of the X-ray beam is passing through the rocket. One computer determines whether the defect is serious enough to justify rejecting the rocket. If the rocket is rejected, a mechanical arm strikes the rocket to mark the place where the defect is located. After leaving the platform, the rejected rockets are removed from the line and repaired.

The X-ray inspector has been a joint project of the Ordnance Ammunition Command, the Mason & Hanger-Silas Mason Co., and General Electric.



DESIGNER TARUFFI in the Tarf II. The two torpedoes are connected by two trusses which act as a pivot for two movable stabilizing planes. The radiator is placed in the back truss. The Tarf II has attained a speed of 185 mph. and has a 240 hp, 4 cylinder, water cooled engine.

Racer Is Part Motorcycle And Car

An unusual looking racer is the Tarf, an Italian car which is a cross between an automobile and a motorcycle. Designed by Piero Taruffi, the car reflects the avocation of its owner—motorcycle and automobile racing.

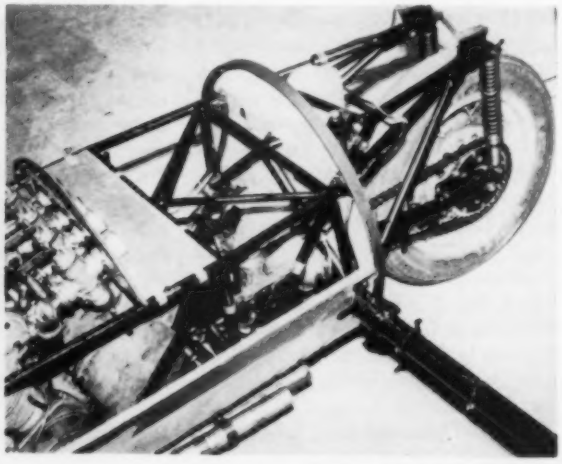
Two models of the racer have been built. The Tarf I has a 4 cylinder Gillera engine, 4 stroke, 550 cc, with 65 hp and no super charging. Tarf II has an old 1750 cc supercharged Maserati engine. Both hold world speed records in their respective groups. Tarf I broke the 100 km world record for the 750 cc group at an average speed of 133 mph. Tarf II holds the record for the 2000 cc group with a speed of 187 mph.

Though similar in design, the two racers differ in several details. In the Tarf I the engine is fitted into the right side of the frame, in Tarf II it is on the left side. Tarf I has a tubular frame; while the frame of Tarf II is made of plates of hard aluminum which also serves as the body.

Transmission on Tarf I is by a double chain connecting the engines with the differential group, and by a single chain which connects the differential with the two backwheels. In Tarf II transmission is through gearing to the differential, and by a double chain from the differential to the two wheels.

The two torpedoes are connected by two trusses which act also as a pivot for two movable planes which add to the car's stability at high speeds.

Taruffi designed his two Tarfs not only to beat some speed records, but to find a solution to the problem of air resistance. In this respect, the front section of the Tarfs measures 0.7 sq meters, where normally the front section of the most streamlined racing cars exceeds 1 sq meter. With the Tarf, it has been possible to attain a form drag coefficient 0.1. In weight, the Tarf I, including the engine, does not exceed 300 kilograms.



THE TARF I with the shell removed. The four speed transmission is controlled by the lever between the driver's knees. Steering levers replace the wheel. The speedometer and tachometer are on the other torpedo. (Right) Transmission and suspension of the Tarf I. A double chain connects the engine and differential, with a single chain to the back wheels.

What Is An Engineer?

In the latest issue of the *News Digest*, a publication of the Engineers and Scientists of America, are reported the results of a test given to mechanical engineers to find out what they think, do, know, likes and dislikes, etc. . . . Given to only 240 engineers in one plant, it showed that:

The engineers had risen to a higher vocational level than their fathers.

Less than 4 per cent of the engineers fall below the mean of the general population in general ability and aptitude, while only ten per cent of the general population reach the mean of the engineers.

Engineers are definitely superior to the general population in verbal intelligence, which is a fact borne out by World War II. Army statistics which show engineers to be one of the most intelligent occupational groups.

On vocabulary only 8 per cent of the engineers fell below the average of the general population.

Engineers are superior in abstract reasoning and in arithmetic reasoning, but in the latter only 20 per cent obtained perfect scores.

Only 2 per cent made perfect scores in mechanical comprehension and less than 5 per cent fell below the norm for applicants for mechanical work.

Contrary to expectations, engineers were no more superior on engineering aptitude tests than they were on tests of general intellectual ability.

In general, engineers are social conformists in both belief and practice.

They are more interested in things than in people.

Few have so-called cultural or aesthetic interests.

They adhere to cold facts and designated steps in performance.

Most of them do not like mathematics per se, and they are not attracted by its theorizing content.

They do not seem to enjoy work where personal relationships are paramount; thus, they stay away from selling, advertising, public relations, or routine office work.

Their language is terse and to the point, for they dislike unnecessary conversation.

Few show interest in the humanities in education.

In space relations, 15 per cent fell below the general population.

In reading, the engineers avoid the so-called "high-brow" magazines, but do not interest themselves in "low-brow" publications either.

Engineers are usually straightforward, direct and self-sufficient, matter-of-fact and unimaginative.

They are seldom tactful. Soft, polite, diplomacy or oblique conciliatory moves are foreign to their nature.

In a word, the engineer, to use one of his own favorite terms, is consistent. He follows a pattern, and he likes life to be a pattern that is symmetrical, logical, visible and vital. For him this is a practical not a personal world.

Automotive News Briefs:

Firestone Tire & Rubber Co. will begin volume production of air springs in the first plant ever specifically designed for that purpose.

The plant is located at Noblesville, Ind., and production will begin by mid-1957, indicating wide use of air suspension system on 1958 cars. It is estimated in Detroit that air springs may well become a $100-million annual business.

More on Fuel Injection

The announcement that American Motors Corp. has purchased Bendix electronic fuel injection units for use in a Rambler car brought admissions from the remainder of the auto industry that they too were considering the possibility of fuel injection.

Ford Motor Co. has had five different systems under consideration for some time. Included are both mechanical and electronic fuel injection systems. Ford does not want to put any fuel injection system in as a running change on 1957 models, but instead, until plans have jelled, will offer a supercharged V-8 engine for all 1957 models (including the Thunderbird) that will raise the horsepower on the Ford to 300.

Chevrolet started mass production of its fuel injection system last month, and fully intends to bring the price down from the current $480 to about $50.

Chrysler is reported to be very close to production model automotive gas turbines, but nevertheless is ready with a fuel injection system (mechanical) in case the public taste switches in that direction. Like Ford, Chrysler does not want to introduce a running change in engines during the model year.

At General Motors:

Pontiac will produce about 1500 cars equipped with a fuel injection system. These will be special sports cars called Bonneville Specials and will not be production models.

Buick will have fuel injection—probably electronic (out of the A-C Div.) and probably before the 1958 models appear.

Cadillac hesitated before deciding on the tried-and-true carburetor system for its new $12,500 model that will appear this month.

Oldsmobile will very likely follow the lead of Buick on any change to fuel injection.

Studebaker-Packard will not make any running changes in the 1957 model line. Curtis-Wright, who has management power over the S-P operation, are concluding agreements with Daimler-Benz that will make C-W agents for the Daimler-Benz products. This could mean that German fuel injection will appear on S-P cars, possibly in the 1958 models.

General Electric's Metallurgical Products Dept. believe American industry will consume between 7 to 9 per cent more cemented carbide metals in 1957. A Recent survey indicated consumption of cemented carbide metals has been steadily increasing at the rate of 5 to 8 per cent a year since 1950. GE management also prophesied that magnetic materials, specialty resistors, vacuum melted alloys (including cemented carbides) should increase approximately 16 per cent for the GE firm during 1957.

Ross Operating Valve Co., producer of air control valves predicts a 25 per cent increase in the production of valves for industrial pneumatics.

TECHNICAL NEWS

Plating for Precision Fitted Bearings

To get exact, vibration resistant bearing fits without having to machine or grind bearings to size, a new plating process developed by Dalic Metachemical Ltd., 121 Leicester Ave., Toronto 18, Canada, can control deposits accurate to within 0.00005 in. With this equipment it is possible to plate only the section of a housing which is to receive the bearing without having to immerse the entire unit in electrolyte.

The unit consists of a special rectifier with a finely graduated voltage control; the cathode lead to the work; and the anode lead to the stylus which applies the plating solution. Several types of styluses are available: plug-type or cap-type, either air or water cooled. Unless the bearing housing is large, one of the smaller air cooled styluses will be adequate.

Plating is done by rotating the housing or shaft in a low-speed lathe (above), if the work is small enough. The cotton swab is dipped into the plating solution and held against the rotating bearing housing. If the housing is too large, the wet stylus can be swabbed around the periphery.

Deposit thickness will vary with the size and type of bearing, and the service to be encountered. In general, a tin plating of about 0.0002 to 0.0005 in. on most surfaces will be enough to give a good fit. Where more of a buildup is necessary, it may be necessary to alternate between various metals in order to do it, i.e., with a difference in mating diameters of more than 0.0055 in., alternate 0.001 in. hard nickel with 0.0001 in. copper to a total thickness of 0.0005 in. Finish off with 0.0005 in. tin.

Entire plating operating of 0.0002 to 0.0005 in. of tin takes about 3 min.

Why Engineers Unionize

According to a study just completed by the National Industrial Conference Board, engineering unions have 60,000 members out of the nation's estimated 500,000 engineers. To determine why unionism has made such inroads in the field of engineering, the Board questioned executives of companies whose engineers were unionized; officials of engineering unions; engineering societies; and engineers themselves.

The findings: engineers are not completely happy with their financial position, their status as professionals, and their treatment as individuals.

Dr. Herbert R. Northrup, Vice-President of Penn-Texas Corp., says that company management can straighten things out by treating its engineers: (1) as members of the management organization by adequate salaries, practical recognition of professional personnel as part of management, and appropriate methods to bring the grievances of professional employees to the attention of top management; and (2) as members of a profession, by including time and facilities for research, study, reading, publishing and otherwise maintaining professional status, and by placing emphasis not on day to day output but on ideas contributed to the long-run worth of the business.

The chief financial complaint of the engineer is that the earnings differential between salaried engineers and wage earners has become too narrow. And in terms of fringe benefits engineers claim that their former advantage over the production worker has been wiped out. Another complaint is that existing salaries for engineers have not kept pace with increases in the hiring salaries of engineers. Engineers often feel that merit sometimes takes a back seat to seniority in determining salary increases.

Engineers joined unions in order to regain the professional status they felt they lost with mass employment, claim the union leaders. Engineering societies also report genuine professional dissatisfaction, but maintain that it stems from the fact that many companies do not put the engineer in a position of being classified as part of the management team.

As professionals, engineers want

better communication with management to clarify their understanding of company policies; credit in reports and papers they help develop; less frequent assignments to jobs requiring little engineering ability; classification as professionals rather than grouping with nonprofessionals; and more training or job rotation so that he can go through the steps necessary for promotion. The engineer objects to being treated on a mass basis in hiring, training, and other employment situations.

The unions which engineers have joined are: (1) The Engineers and Scientists of America, an independent, professional union which claims 30,000 members; (2) The American Federation of Technical Engineers, an AFL-CIO semi-professional union organized especially for engineers and others with related skills and claiming over 15,000 members; and (3) production workers such as the UAW, the United Steelworkers and the International Union of Electrical Workers.

Auto Gets Water Injection To Reduce Smog

Shooting a fog mist of tap water into a carburetor's air intake is a new way to eliminate smog caused by automobiles, according to R. D. Kopa, professor of thermodynamics at the Univ. of Calif., Los Angeles. The device, developed by Prof. Kopa and a team of research students, is designed to eliminate the oxides of nitrogen, one of three elements (hydro-carbons and sunshine) considered to be important in the eye stinging smog formation.

Oxides of nitrogen are formed during combustion at high temperature, and water mist reduces the heat at peak temperature to reduce the oxide formation. Kopa uses about ½ gal of water to one gal of gasoline. In tests carried out over past year on a V-8 engine, oxides were reduced by 90 per cent without affecting the power or efficiency of the engine.

Water injection has been used for years in aircraft and racing cars, but Kopa believes that this is the first time that it has been used with the smog problem fn mind. Cost of the device will be about $50.

Iron Particle Magnet to Aid Instrument Design

Ordinary iron in the form of submicroscopic, elongated particles have been used by the Instrument Dept. of General Electric Co. to make a new type of magnet. Not much more than iron dust (it can be seen only with an electron microscope), theoretically the ultra-fine particle iron magnet can be made ten times stronger than available magnets, according to Dr. T. O. Paine of G. E.

The new magnet will permit the design of electric instruments that are smaller, lighter, more accurate and more rugged. It will result in better photographic exposure meters, aircraft instruments, and other products using permanent magnets. However, it will be quite some time before such magnets are commercially available.

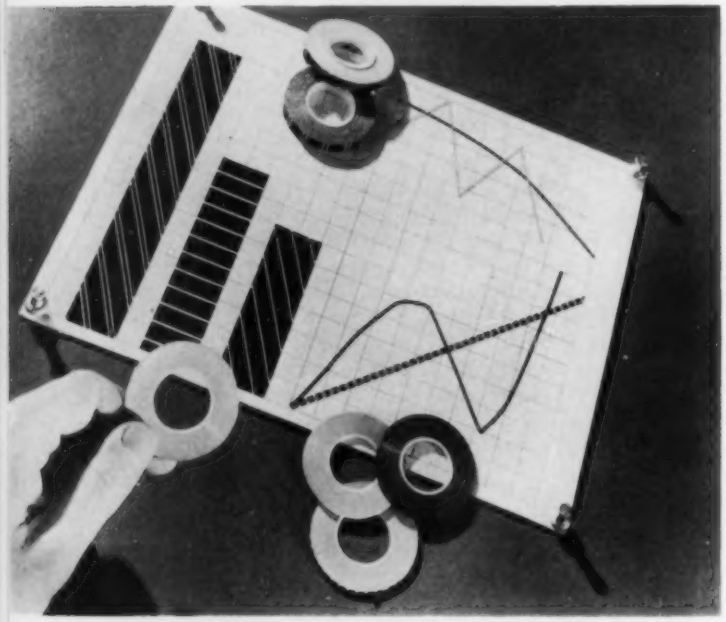
The iron particles can be embedded in plastics, metal, rubber, or glass, and are easily machined, drilled, tapped, soldered, and molded into any shape. Also, the magnetic and mechanical properties can be accurately controlled. Another advantage is that strategic materials like nickel and cobalt are no longer required. The lack of cobalt also permits the use of these magnets in nuclear reactors, where the magnets are not used because of high induced radioactivity.

Permanent magnets require a material with a wide hysteresis loop, and a material in which magnetic domain boundaries move only with great difficulty. Thus, the magnet will retain its flux even under strong demagnetizing fields. A good way to prevent domain-boundary movement involves the use of highly elongated iron particles. To demagnetize an elongated particle, an additional field must be created at the sides of the particle. The energy required to do this leads to a high resistance to demagnetization.

Both the size and the elongated shape of the particles must be closely controlled to achieve this resistance to demagnetization. When this is done, unusual properties are attained. Although these particles have exactly the same chemical composition and crystal structure as ordinary iron, their resistance to demagnetization is 100 times greater than ordinary iron.

To get these particles into a magnet requires that they be first aligned by a powerful magnetic field, and compacted with a suitable binder.

THE NEWS IN PICTURES



◀ THE APPEARANCE OF engineering charts and graphs will be improved with a new series of adhesive acetate fiber tapes of various widths, colors, and designs. The tapes can be applied to almost any surface, and the narrower widths can be curved. Tapes come in 15 different colors, six widths, and nine striped designs. Tape widths range from 1/32 in. to 1 in. Tape manufacturer is the American Chart Service, Inc., 101 Dover St., Somerville 44, Mass. The tapes can be peeled off easily. Slitting the tape to narrow widths was made possible by mounting the tape on flexible core tubing.

CYLINDRICAL PLASTIC SHAPES can be whirled out at low mass cost by an unusual machine developed by the Patushin Aviation Corp., 5651 West Century Blvd., Los Angeles 45, Calif. Known as the glass fiber resin process (GFR), the machine was nicknamed the "carousel" because of its rotation of as many as six tubular molds at high velocities. The machine distributes controlled amounts of resin and chopped fibers simultaneously, and turns out parts as large as 10 ft long by 44 in. dia, one every ten minutes, with a single operator. The GFR forms parts out of round as much as 20 per cent between major and minor axis and molds in integral stiffeners. Some uses: containers, aircraft fuel tanks, chemical containers.

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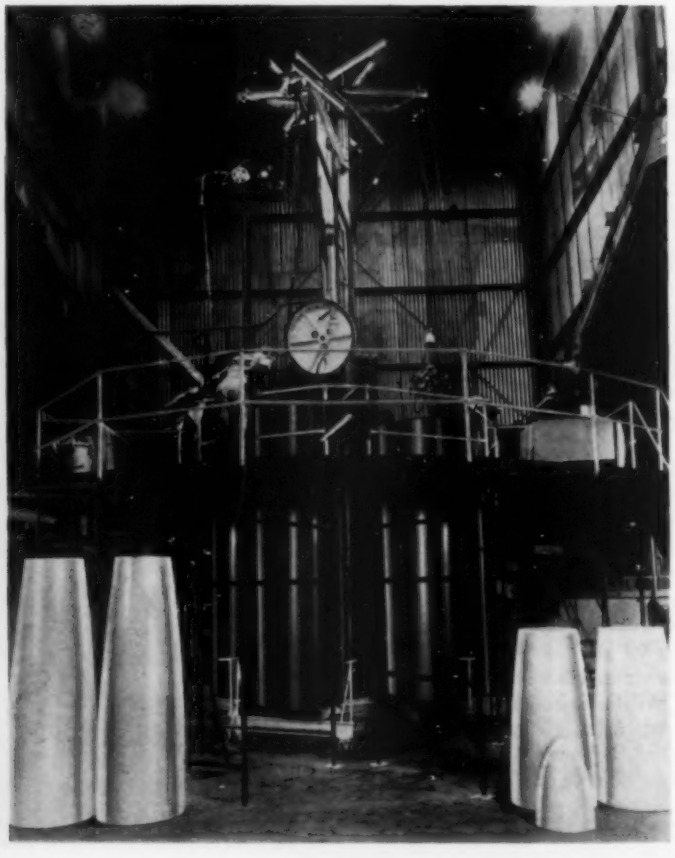

WHEN PUSHED INTO the "play" position on this player, tape threading is accomplished automatically with this long play (one hr) tamperproof cartridge just announced by Cousino, Inc., 2107 Ashland Ave., Toledo 2, Ohio. The cartridge is also ejected automatically with the tape rewound, ready for the next play and retracted to prevent tangles or tampering. As in conventional tape recording, the recordings in the cartridge can be erased and re-recorded. The front or loading end of the new cartridge is identical to the original half-hour Echo-Matic model 410 to be compatible with machines already using the cartridge principle. The endless loop principle, permits other designs including a pocket tape recorder, a telephone answering system, or an automobile dashboard player and recorder.

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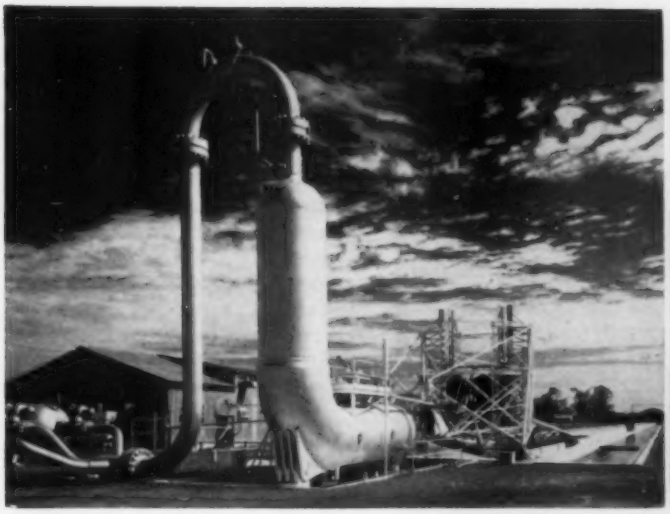

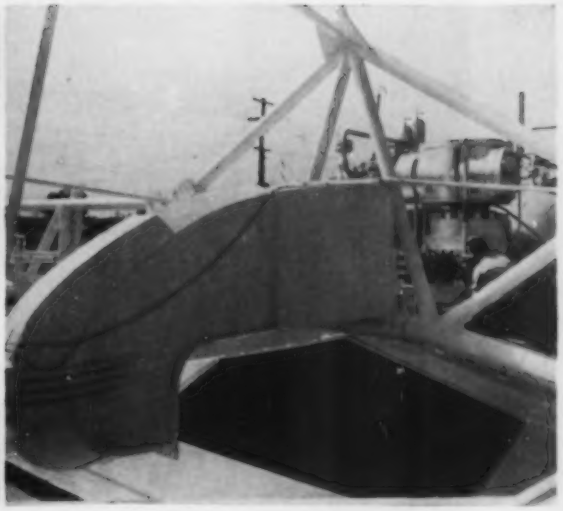

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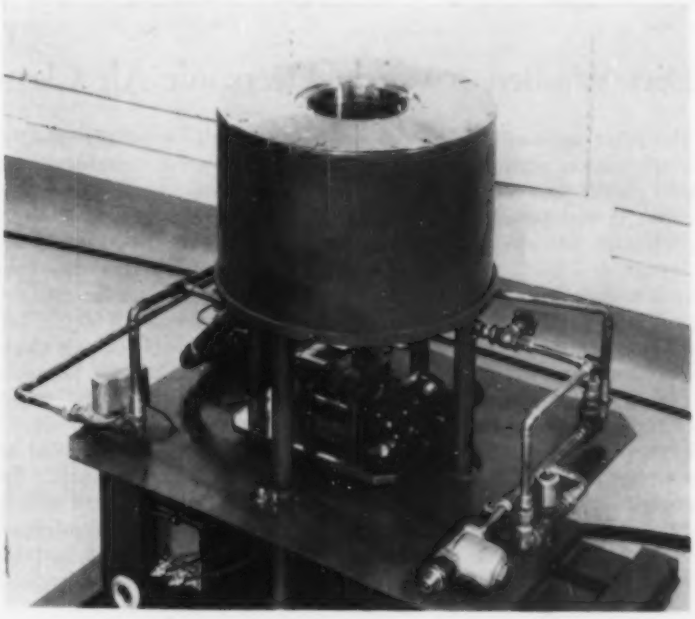
AIRCRAFT LANDING PROBLEMS are studied by the National Advisory Committee for Aeronautics at its Langley Field, Va., laboratory using this hydraulic jet apparatus. A 50 ton carriage on which an airplane landing gear is installed is catapulted at speeds up to 150 mph along a 2200 ft track. When ready for a test run, the carriage is positioned at a nozzle on an L-shaped tank (center, picture at left) which contains water under 3260 psi air pressure. The water shoots out of the 7 in. nozzle at a velocity of 660 ft per sec and is directed into the specially shaped bucket on the carriage (photo at right). The water jet undergoes a 180 deg change of direction and falls out the bottom of the bucket, producing in the process a thrust on the carriage of 400,000 lb. The carriage is accelerated to 150 mph within 400 ft and 3½ sec. After the catapult, the carriage coasts along the track for 1200 ft to a simulated landing, and is stopped within the last 600 ft by arresting cables. The equipment being tested drops on the test rig until the desired vertical velocity is obtained. Just before ground contact, an engine applies a vertical force to simulate an aircraft's wing lift. Data is obtained on: the landing gear as a shock absorber; the nature of the skidding during wheel spin, and the elastic behavior of tires in yawed rolling. The hydraulic jet system is economical. It costs less than five dollars per shot to operate as compared to a rocket powered system costing about $6000 per shot.



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THE FIRST OF ITS KIND at the Los Alamos Scientific Lab of the Univ. of Calif., this portable critical assembly machine called the "hydro" is water cooled and capable of operating at power levels up to 3 kw. Such machines, conceived at Los Alamos during research for the atomic bomb, are actually small, versatile experimental reactors which bring together enough fissionable material to form a chain reacting critical mass. They can be used to determine the criticality of various materials and shapes, supply large quantities of neutrons and for studying the effects of surrounding and interspersed materials. About the size of an armchair, its portability permits its use outdoors to avoid undesirable effects of neutron scattering and reflection from surrounding walls. As it remains radioactive for some time after its use, it is lowered into a shielded outdoor storage pit.

THE ELECTRONIC CELL carrying the 13,000 v charge is shown inside the air cleaner at right. Entire section can be pulled out by handle on front for inspection. After dust is collected on the collector plates, it is automatically washed off by water spray. Air cleaner shown here is installed directly in heating or ventilating system.

Dirt Washed Away in Electronic Air Cleaner

The latest in electronic air cleaners which collects airborne dirt down to sizes smaller than the smallest known virus. As dust particles flow into the electronic air cleaner, they pass through a 13,000 volt electrostatic field where they receive a positive electrical discharge. This overbalances the negative charge surrounding the dust atom, making it a positive ion.

The positively charged ions are attracted to negatively charged collector plates carrying 6500 volts and are repelled by alternately placed positive plates in the collector unit. After collecting on the negative plates, the dust particles are automatically washed away by a water spray.

The electronic air cleaning units are installed in the ductwork of the modern heating, ventilating, and air conditioning system. They are available in various sizes and can be arranged so their air handling capacity exactly matches the air handling capacity of the system fans. With this arrangement, all of the air will be drawn through the air cleaner at the correct velocity for the most efficient elimination of the impurities. One cell unit will cost $600, and at the outset will be aimed at the Commercial building field. Specific industries like instrument manufacturing plants, pharmaceutical buildings, laboratories, as well as hospitals are potential customers. Units for home use will come later.

Graduating Engineering Students Look For—

continuous opportunities to work on worthwhile and stimulating problems within their potential abilities, plus the possibilities of taking on increased responsibilities. These, according to a report by D. S. Dabb and M. S. Helm of the Univ. of Illinois, Urbana, Ill., are the primary considerations of the graduating electrical engineer looking for employment.

Presented at the Winter General Meeting of the AIEE in New York last month, the report points out that the majority of students are not unduly influenced by glittering promises of bonuses, fringe benefits, or employee conveniences. Students are skeptical of such companies and are becoming increasingly wary of those industries that offer traditionally high starting salaries without job security. "Security," according to the report, is not thought of by the student as merely being retained on a company payroll, but is regarded in terms of chances to advance according to ability, and to develop professionally and creatively.

Babb and Helm also gleaned from the remarks of the students that engineering needs more publicity, and that there are two times in the life of a student when this publicity is needed. The first is while the student is in elementary and secondary schools, and the second while he is in engineering college.

The problem of publicity to the engineering students requires answers to the following questions: (1) What can be done to acquaint the student with present day engineering problems and the part he will play in solving these problems; (2) What can be done to get across to the student the needs and work of engineers in companies where the name of the company does not suggest the need; (3) What should company brochures contain to be of most use to the student; (4) What changes should be made in the interviewing methods; (5) What should be the nature of summer employment offered to the undergraduate students; and (6) What help do the colleges need from industry in order to keep up with rapidly changing developments and their effect on the requirements for new personnel.

COMING EVENTS

FEBRUARY 14–15

Transistor and Solid State Circuits Conference, sponsored by IRE and AIEE, Univ. of Pa., Philadelphia, Pa. Sessions are grouped under: Switching Circuits; Computer Switching; Linear Amplifiers; Power Circuits; and Special Device Circuits.

FEBRUARY 15–16

Spring Meeting, National Society of Professional Engineers, Hotel Francis Marion, Charleston, S. C.

FEBRUARY 19

13th Annual Quality Control Clinic, Rochester Society for Quality Control, War Memorial, Rochester, N. Y.

FEBRUARY 26–28

The 1957 Western Joint Computer Conference, Statler Hotel, Los Angeles, Calif. Under the joint sponsorship of the IRE, AIEE and ACM, the theme of the meetings will be "Techniques for Reliability."

MARCH 6–8

Spring Technical Meeting, Pressed Metal Institute, Carter Hotel, Cleveland, Ohio.

MARCH 11–15

The 1957 Nuclear Congress, Conventional Hall, Philadelphia, Pa. Expected to attract engineers and scientists from all over the world, the Congress has as its purpose, the promotion of the use of atomic energy for peaceful purposes in all the nations of the world. The 5th Atomic Energy for Industry Conference will be held in conjunction with the Congress. Over 200 exhibitors will display equipment. In the engineering and science sessions will be 130 technical papers dealing with all phases of nuclear operations. Emphasis will be on new developments of potential value to civilian industry, especially in the field of metallurgy, chemical processing and power application.

MARCH 12–20

Quality Control by Statistical Methods, a basic course to be conducted at the Georgia Institute of Technology. For further information write to Coordinator, Short Courses & Conferences, Georgia Institute of Technology, Atlanta, Georgia.

MARCH 13–15

Spring Meeting of the National Fluid Power Association, Hollywood Beach Hotel, Fla.

MARCH 18–21

SPI Annual National Conference and Pacific Coast Plastics Exposition, Los Angeles, Calif. Sessions will be held at the Hotel Biltmore, on plastics in the fields of electronics, aircraft and defense, packaging, building materials, appliances, sheet and cellular plastics, in addition to the latest developments for processes and processing. The Exposition will be held at the Shrine Exposition Hall.

MARCH 18–21

Military Automation Exposition, Trades Show Bldg., New York City. Exhibitors will be chiefly manufacturers and suppliers of components, subassemblies and manufacturing equipment used by the military or manufactured by prime contractors to military specifications. No classified items will be shown. Nearly half of the equipment to be exhibited will be electronic. Instrumentation will be emphasized.

MARCH 18–21

Institute of Radio Engineers, National Convention and Radio Engineering Show, Waldorf-Astoria Hotel and the New York Coliseum, New York City. A program of 55 technical sessions is being set up by the committee; 33 sessions will be held at the Waldorf and 22 at the Coliseum. Two highlight sessions, "Future Use of Air Space" and "Microminiaturization–The Ultimate Technique" will be held the evening of March 19th.

MARCH 25–27

American Society of Tool Engineers, Silver Anniversary Technical Meeting and Convention, Shamrock Hilton Hotel, Houston, Texas. Will include symposiums on Ceramic and Plastic Tooling, and technical papers.

MARCH 25–29

10th Western Metal Congress and Exposition, Pan-Pacific Auditorium, Los Angeles, Calif. The Congress will be held in the Ambassador Hotel. To be held simultaneously by ASM's Metals Engineering Institute is a Titanium Conference. It will be an up-to-date repeat of the first one given at the university level two years ago in cooperation with New York University. Titles of daily discussions during the week are: "Applications, Design and Cleaning"; "Forming"; "Machining"; "Welding and Brazing"; "A Look Into the Future."

APRIL 1–2

5th Midwestern Conference on Fluid Mechanics and the 3rd Midwestern Conference on Solid Mechanics, held concurrently at the Univ. of Michigan, Ann Arbor, Mich.

APRIL 8–12

5th Welding and Allied Industry Exposition, Convention Hall, Philadelphia, Pa. Held concurrently will be the National Spring Meeting of the American Welding Society. A total of 18 sessions are planned: welding problems in the design and fabrication of nuclear reactors and reactor components; effect of neutron radiation on weldability and mechanical properties of structural metals; welding of titanium and zirconium; brazing stainless steels and high temp. alloys.

APRIL 11–13

Southwestern IRE Conference and Electronics Show, Shamrock Hilton Hotel, Houston, Texas.

APRIL 14–27

United States World Trade Fair, Coliseum, New York City.

APRIL 24–25

Second National Research Conference, Conrad Hilton Hotel, Chicago, Ill. Sponsored by Armour Research Foundation of Illinois Institute of Technology, 9 papers will be presented on: Sales Growth Through Research; More Research for the Dollar; Extra Dividends from Research.

Financial Aid to Higher Education

A Fine Start, But...

This editorial has two purposes. The first is to salute American business for the fine start it has made in helping to relieve the financial plight of our colleges and universities. The second purpose is to stress the importance of having business provide more financial aid, and soon.

How Business Helps Higher Education

Business contributions to higher education doubled between 1950 and 1955. They jumped from $40 million to $80 million. Preliminary figures indicate they will be even higher this year.

Business firms have also shown a lot of ingenuity in devising different ways of making their contributions. The methods range from a matching of an employee's contribution to his particular alma mater to wide diffusion of the money through state and regional money-raising associations of colleges and universities. Thanks to this ingenuity, business firms now have a wide choice of ways by which to give effective aid. The way most appreciated by college administrators is the making of gifts unrestricted as to the purpose for which the money is used.

Imposing as it is, however, what business has done thus far is only a good start. Only a tiny fraction of the total number of business firms in the country are giving direct financial help to our colleges and universities; and this fraction includes fewer than half of the hundred largest corporations in the country. Also, the amount of financial help being provided by business constitutes only a very small fraction of what is needed.

Why Colleges Need More Aid

Right now our privately endowed colleges and universities need about $350 million more in operating income a year than they are receiving to enable them to pay decent faculty salaries and be in tolerably good working order otherwise. The reasons, including a severe decline in the purchasing power of their endowment income because of price inflation, have been dealt with in the previous editorials in this series.

In addition, these institutions, together with the tax-supported schools, are faced with a tremendous increase in enrollment over the years ahead. With both a rapidly increasing population of young people and an increasing propor-

tion of them going to college, this year's enrollment of 3.2 million students is expected to reach 4.0 million by 1960, and to be doubled by 1970.

For the next ten years our privately supported colleges and universities must have an average of about $400 million a year above what they can be expected to collect from tuition fees, income from endowment funds, etc.

This figure of $400 million does not include what is needed for new buildings and equipment. It also does not include help for tax-supported schools above what they get from taxes, fees, etc. Business has given and will continue to give these schools substantial aid. Indeed, almost 25% of the financial help from business for our colleges and universities went to tax-supported schools in 1955.

If aid from business met their needs for increased operating income, the privately supported colleges and universities would be given a decisive lift in performing successfully their part in our system of higher education. They would still have large needs of capital equipment — buildings, dormitories, laboratories — but help from other sources, such as that provided by devoted alumni, where they are well organized, could be expected to go far toward meeting these needs. Also some companies prefer to concentrate on meeting needs of this type.

What 1% of Profits Would Do

But do business firms have the capacity to fill the gap in adequate operating income for our privately endowed colleges and universities without putting an excessive financial burden on themselves? Those who have studied this capacity carefully say that the answer clearly is yes. If, of its profits before taxes — last year an estimated $43 billion — business were to devote 1% to helping our privately endowed colleges, it would take care of present operating needs of about $350 million a year. And the balance of $80 million would be a big step in meeting their needs for new buildings and equipment, too.

About one half of a 1% contribution of this sort would, in effect, be made by the federal government. Up to a limit of 5%, contributions of this type are exempt from the federal corporate income tax. For corporations with incomes above $25,000 per year this tax is 52%.

It is clear that not all business firms are in shape to devote 1% of their profits to aid to higher education. Even in this year of record-breaking prosperity, many of them will have no profits at all. But if business generally would take 1% of pre-tax profits as a target or benchmark for financial help to our privately endowed colleges and universities these institutions would again have sturdy financial foundations.

Relatively this is a very small price to pay (1) to insure a continuing supply of competently trained young men and women and (2) to buttress our freedom by assuring the successful survival of the privately supported sector of our system of higher education.

This is one of a series of editorials prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments of particular concern to the business and professional community served by our industrial and technical publications.

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Donald C. McGraw
PRESIDENT

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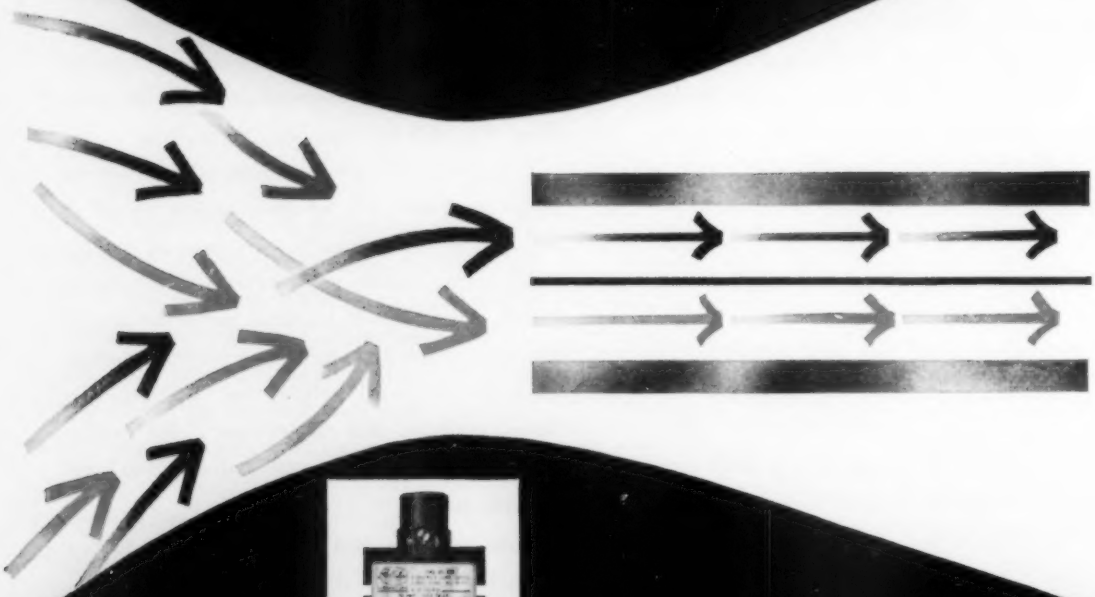
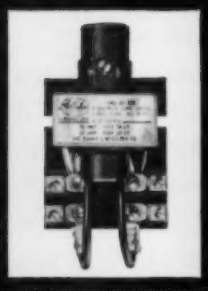
When you need Reliable Control of Movement





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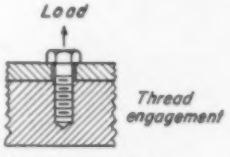
Stripping Strength of Tapped Holes

FRANCIS KULL
Project Engineer, Standard Pressed Steel Co.

Charts and sample problems for obtaining minimum thread engagement based on applied load, material, type of thread and bolt diameter.

KNOWLEDGE OF THE thread stripping strength of tapped holes is necessary to develop full tensile strength of the bolt or, for that matter, the minimum engagement needed for any lesser load.



Conversely, if only limited length of engagement is available, the data help determine the maximum load that can be safely applied without stripping the threads of the tapped hole.

Attempts to compute lengths of engagement and related factors by formula have not been entirely satisfactory—mainly because of subtle differences between various materials. Therefore, strength data has been empirically developed from a series of tensile tests of tapped specimens for seven commonly used metals including steel, meehanite, aluminum, brass and cast iron.

The design data is summarized in the four accompanying charts, (Figs. 1-4), and covers a range of screw thread sizes from #0 to one inch in dia for both course and fine threads. Though developed from tests of Unbrako cap screws having minimum ultimate tensile strengths (depending on the diameter) from 165,000 to 200,000 psi, these stripping strength values are valid for all other screws or bolts of equal or lower strength having a standard thread form. Data are based on static loading only.

In the test program, bolts threaded into tapped specimens of the metal under study were stressed in tension until the threads stripped. Load at which stripping occurred and the length of engagement of the specimen were noted. Conditions of the tests, all of which are met in a majority of industrial bolt applications, were:

Tapped holes had a basic thread depth within the range of 65 to 80 per cent. Threads of tapped holes were Class 2B fit or better.

Minimum amount of metal surrounding the tapped hole was 2½ times the major diameter.

Test loads were applied slowly in tension to screws having standard Class 3 or 3A threads. (Data, though, will be equally applicable to Class 2A external threads as well.)

Study of the test results revealed certain factors that greatly simplified the compilation of thread stripping strength data:

Stripping strengths are almost identical for loads applied either by pure tension or by screw torsion. Thus data are equally valid for either condition of application.

Stripping strength values vary with diameter of screw. For a given load and material, larger diameter bolts required greater engagement.

Minimum length of engagement (as a percent of screw diameter) is a straight line function of load. This permits easy interpolation of test data for any intermediate load condition.

When engagement is plotted as a percentage of bolt diameter, it is apparent that stripping strengths for a wide range of screw sizes are close enough to be grouped in a single curve. Thus, in the accompanying charts, data for sizes #0 through #12 have been represented by a single set of curves.

With these curves, it becomes a simple matter to determine stripping strengths and lengths of engagement for any condition of application. A few examples are given below:

Example 1. Calculate length of thread engagement necessary to develop the minimum ultimate tensile strength (185,000 psi) of a ¼-13 (National Coarse) Unbrako cap screw in cast iron having an ultimate shear strength of 30,000 psi. Fig. 1 is for screw sizes from #0 through #12; Fig. 2 for sizes from ¼ in through ⅝ in.; Fig. 3 for sizes from ¾ in. through 1 in. Using Fig. 2 a value 1.40D is obtained. Multiplying nominal bolt diameter (0.500 in.) by 1.40 gives a minimum length of engagement of 0.700 in.

Example 2. Calculate the length of engagement for the above conditions if only 140,000 psi is to be applied. (This is the same as using a bolt with a maximum tensile strength of 140,000 psi) From Fig. 2 obtain value of 1.06D. Minimum length of engagement = (0.500) (1.06) = 0.530 in.

Example 3. Suppose in Example 1 that minimum length of engagement to develop full tensile strength was not available because thickness of metal allowed tapped hole of only 0.600 in. Hole depth in terms of bolt dia = 0.600/0.500 = 1.20D. By working backwards in Fig. 2, maximum load that can be carried is approximately 159,00 psi.

Example 4. Suppose that the hole in Example 1 is to be tapped in steel having an ultimate shear strength of 65,000 psi. There is no curve for this steel in Fig. 2 but a design value can be obtained by taking a point midway between curves for the 80,000 psi and 50,000 psi steels that are listed. Under the conditions of the example, a length of engagement of 0.825D or 0.413 in. will be obtained.

(continued on page 217)

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Stripping Strength of Tapped Holes (continued from page 215)

Fig 1 – Thread Stripping Strength in Various Materials

For Screw Sizes No. 0 thru No. 12 Fine and Coarse Thread

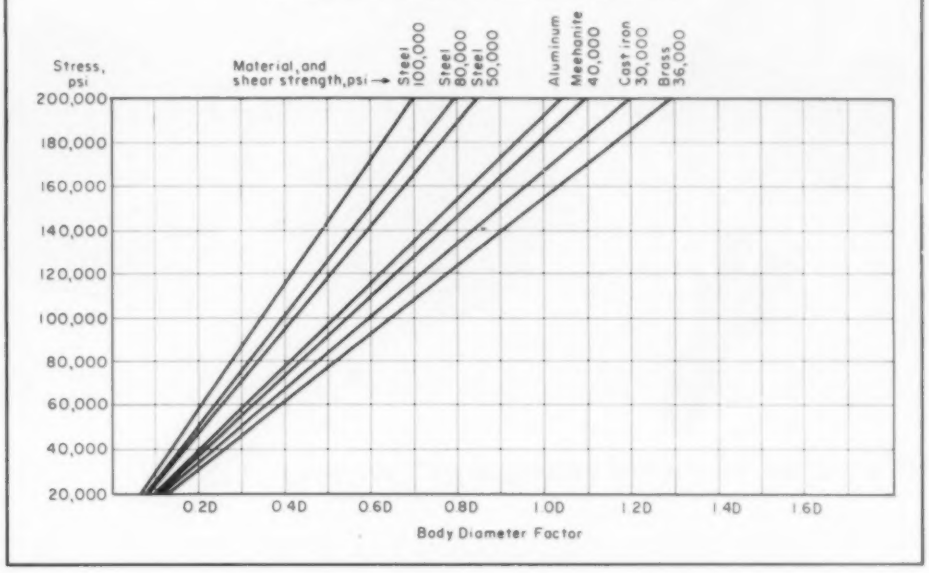
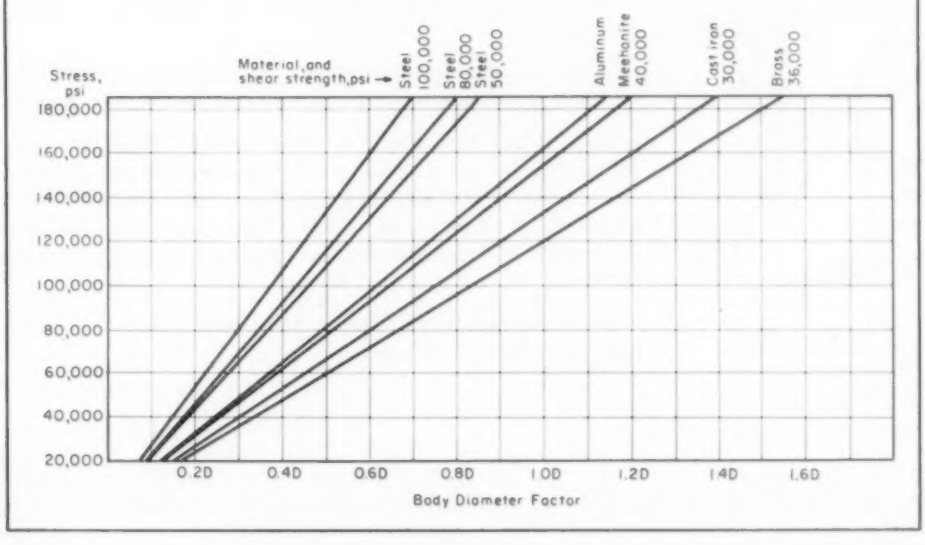


Fig 2 – Thread Stripping Strength in Various Materials

For Screw Sizes $\frac{1}{4}$" thru $\frac{5}{8}$" dia – Coarse Thread



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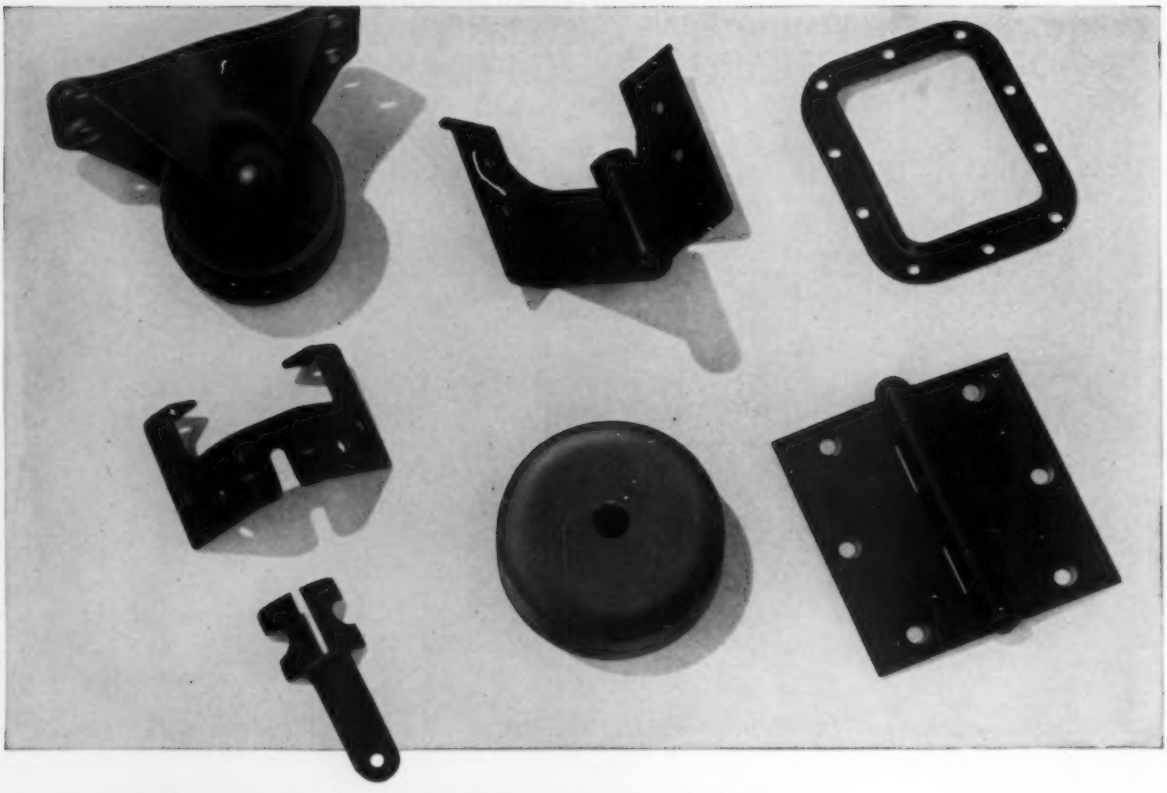
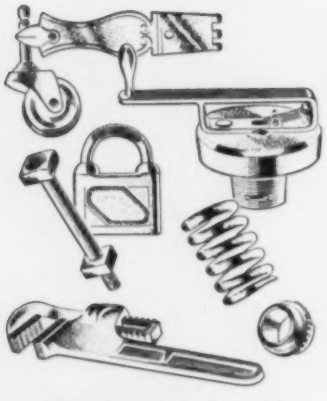


A manufacturer of metal stampings* writes:

"There are many outfits offering something like Parkerizing, but we want the real thing."



Some typical parts which are protected from rust by treatment with Parco Compound

Parco Compound† (Parkerizing†) is the original rust-resistant phosphate coating for iron and steel. For forty-two years it has protected hundreds of different types of products—from bolts to boats.

There are other products "like" Parkerizing, but none quite so effective, so dependable, so thoroughly tested and proven.

Parkerizing is simple, fast, and costs very little. It can be used on any iron or steel article which can be immersed in the tanks. Since it does not change the dimensions of the treated parts, it is excellent for threaded or close-fitting components. Parts treated with Parco Compound may be finished with stains, waxes, oils or paint.

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**Name on request.*

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corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

Stripping Strength of Tapped Holes (continued from page 217)

Fig 3 – Thread Stripping Strength in Various Materials
For Screw Sizes $\frac{3}{4}$" thru 1" Coarse Thread

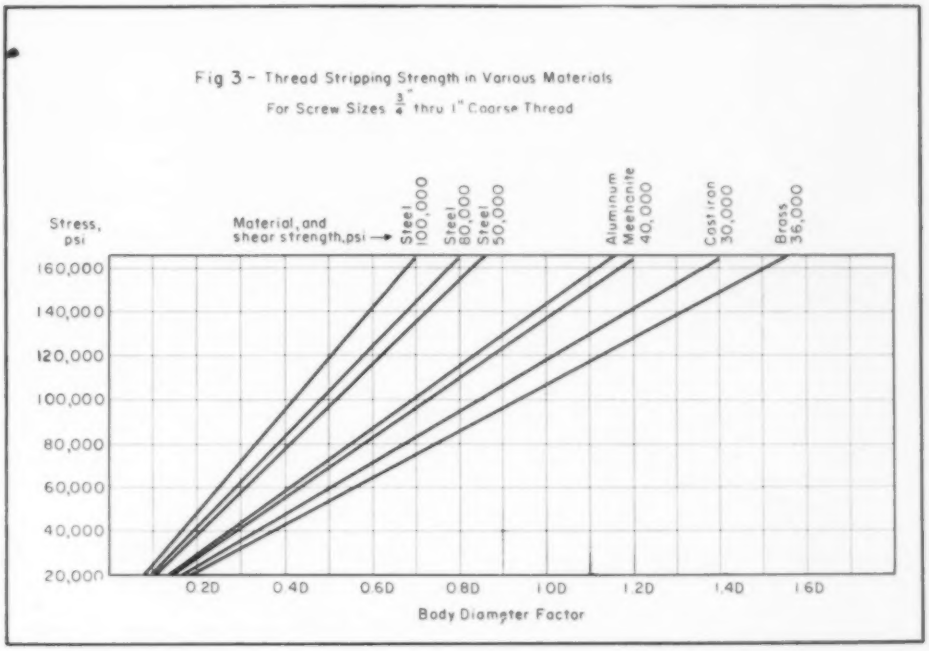
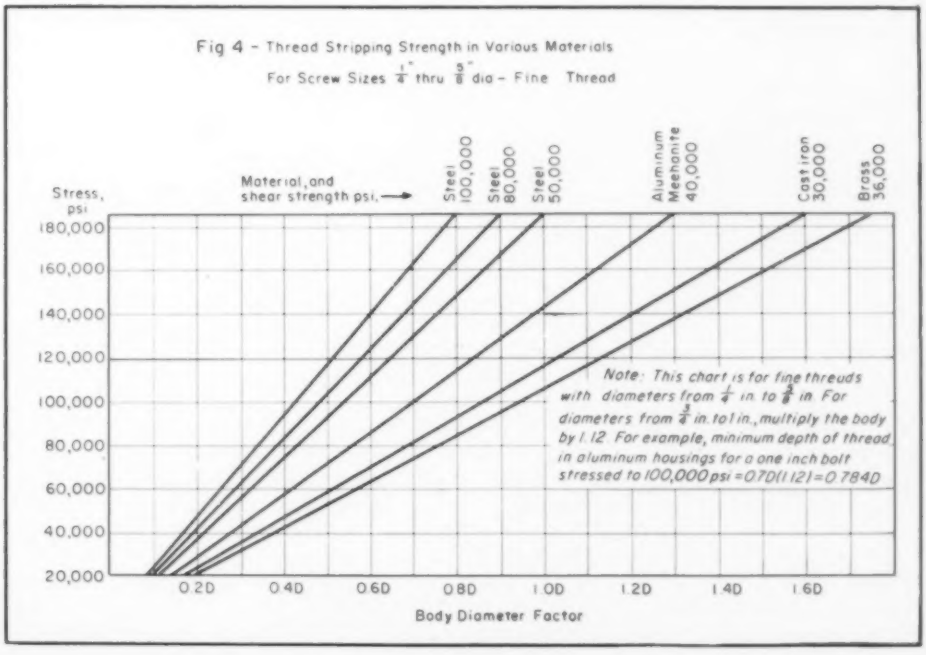
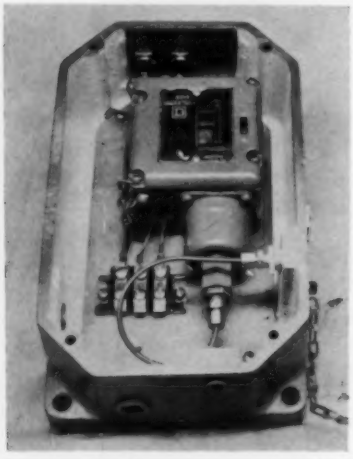


Fig 4 – Thread Stripping Strength in Various Materials
For Screw Sizes $\frac{1}{4}$" thru $\frac{5}{8}$" dia – Fine Thread



NEW COMPONENTS



Guards Against Lubrication Failure

The unit automatically stops machinery when lubrication pressure drops below a predetermined setting. The machinery completes the working cycle before stopping, thereby eliminating tool, cutter, die or knife damage or breakage. The machinery cannot then be restarted until the cause of failure has been corrected, and pressure restored.

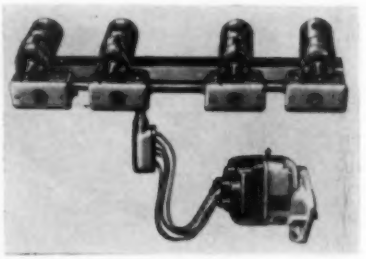
The unit contains standard electrical connections (conforming to JIC and NMTBA standards) which are easily applied to present circuits. It is applicable to any type of machinery requiring protection against loss of pressure in forced feed lubrication systems. This new safety device is tamper-proof. Seneca Falls Machine Co., Seneca Falls, N. Y.

For more information—
Circle 1, inside back cover

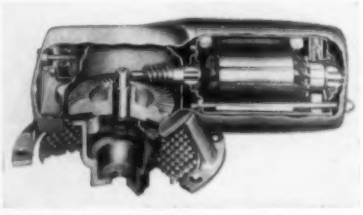
Low Tension Ignition System

A line of ignition systems for nearly all large spark-ignited engines of two, three, four, six and eight cylinders consists of a low-tension magneto with individual high tension ignition transformers mounted at each cylinder. Because only a low voltage is present there is said to be no problem with either ozone or high corona discharges within the magneto case. Bearings and all other parts last longer since corrosion products and lifeless lubricants that are common problems in high tension setups are not encountered. Excess arc, common to battery and magneto systems, is also absent.

Installation is simple since the low-tension magneto is no larger than a standard unit and timing and mounting present no difficulties. Factory-built harnesses can be furnished for most engines and can be installed in a few minutes. These harnesses are complete and include: transformers, junction boxes, mounting hardware, lead wires. They may be ordered for nearly all popular engines up to 4000 cu in. displacement. Fairbanks, Morse & Co., Beloit, Wis.



LOW TENSION ignition system and harness for four-cylinder engines



CUTAWAY OF battery-powered starter for small gasoline engines.

For more information—
Circle 2, inside back cover

Mill Forms from Metal Powder

A process for making wrought products from metal powders provides compositions of metallic mixtures to specific requirements. Shapes such as strips, bars and tubes of long lengths are available. Critical metallic or non-metallic ingredients can be added to the compositions in a more uniform dispersion than is possible by melting, according to the manufacturer. Metals handled include aluminum, copper, nickel, cobalt, carbon steel, stainless steel and their alloys.

It is also possible to produce wrought materials with a homogeneous structure, even though the original ingredients of the powder mixture are partially or totally insoluble in each other. Specific properties, such as required in electronic, nuclear, electrical and high temperature applications, can be satisfied by the judicious use of uniformly dispersed additives.

Porosity is reported to be completely absent in these new materials. Any symmetrical shape, such as strips, bars, rods, wires, foil and tubes, can be made by the new process. Strip is already available in lengths of 20 ft or more.

To produce these mill forms, homogeneous metal powder mixtures are pressed into ingots and then processed into desired shapes. Sintercast Corp., Yonkers, N. Y.

For more information—
Circle 3, inside back cover

Belleville Spring Cartridge

Pre-assembled stacks of Belleville spring washers, held together by pins or rivets passing through the washers at or near their neutral axis can be pre-loaded so that only a slight additional compression force is necessary to assemble the unit in the machine. The three-point (or more) loading of the cartridges prevents buckling of the stacks. Possible applications include shock-absorber service, to exert large amounts of force within a limited range of deflection, to exert force at a low rate, to maintain reasonably con-

stant pressure in spite of expansion due to temperature variations.

Belleville washers are used for two fundamental purposes: 1) to get high loads with relatively small deflections; 2) to get a special load-deflection curve. Associated Spring Corp., Bristol, Conn.

For more information—
Circle 4, inside back cover

Flush or Recessed Control Mount

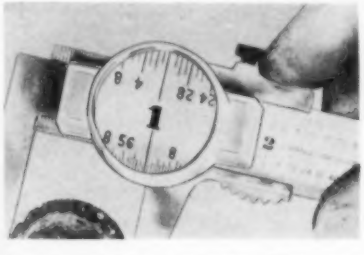
A method of panel-mounting such controls as potentiometers, trimmer condensers, switches, and tuned coils so that slotted shafts are flush or recessed is said to prevent tampering or accidental change of position. This device consists of two parts: a narrow-flanged bushing with internal thread to fit the shaft-bushing of the mounted device, and a spring bracket that applies force between the mounted device and the back of the panel.

The unit mounts in a $\frac{7}{16}$ in. hole for a control with a $\frac{1}{4}$ in. shaft or in a $\frac{3}{8}$ in. hole for a control with a $\frac{1}{8}$ in. shaft. The standard unit is designed for use with up to $\frac{1}{8}$ in. panels. Waters Mfg., Inc., P.O. Box 368, S. Sudbury, Mass.

For more information—
Circle 5, inside back cover

Magnifying Glass With Permanent Magnets

This device consists of a butyrate transparent housing $1\frac{1}{8}$ x $\frac{13}{16}$ in. high in which is sealed a 6X, non-distortion lens. Protruding from two sides of the housing are small extensions containing permanent magnets. The unit comes with a plastic case with snap. The glass mounts instantly on any ferrous metal gage or rule for magnifying fine calibrations.

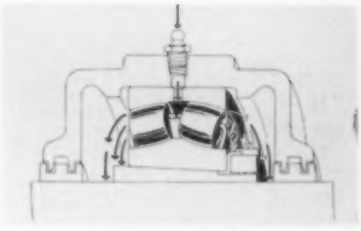


The magnets maintain the glass in position, whether vertical, horizontal or upside down, until altered. Even heavy vibration is said not to jar the magnifier loose. The housing is shatterproof and the lens is set $\frac{1}{8}$ in. below the top to reduce scratching. Magnaglass Mfg. Co., Inc., Fredonia, N. Y.

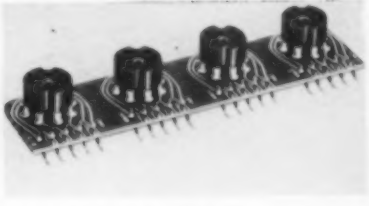
For more information—
Circle 6, inside back cover

Center-Lubricated Spherical Bearings

Available in spherical roller bearings of 5.5118 in. OD and larger, lubrication is accomplished by means of a groove machined around the circumference of the bearing outer ring. Equally spaced holes drilled in the ring channel the lubricant from the groove to the center of the bearing. SKF Industries, Inc., Front St. and Erie Ave., Philadelphia 32, Pa.



For more information—
Circle 7, inside back cover



Right-Angle Printed Circuit Mounting

A multiple right-angle socket mounting for use in conjunction with printed circuits can be used for two, three, four sockets, and can be applied to the mounting of electronic components such as resistors and capacitors not previously a part of a circuit. Cleveland Metal Specialties Co., 1783 E. 21 St., Cleveland 14, Ohio.

For more information—
Circle 8, inside back cover

Screwdriver-Operated Switch

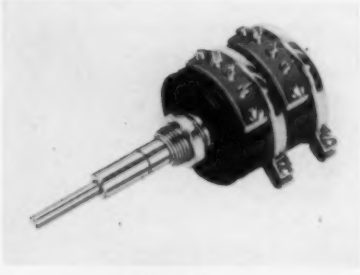
A switch that can be installed in limited-access areas and actuated by a screwdriver has a slotted actuator head, with 90-deg rotation, that gives visual indication of switch position. Its bushing permits one-hole mounting in panels up to $\frac{3}{32}$-in. thick. The assembly is available with any of the variations of the subminiature switch, such as high-temperature versions, long-life

CONTINUED ON PAGE 222

versions, and variations equipped with special terminals.

The switch is UL-listed for 5 amp, 125 or 250 v a-c, or 3 amp, inductive, 30 v d-c. Micro Switch, Freeport, Ill.

For more information—
Circle 9, inside back cover



Concentric-Shaft Potentiometers

The concentric-shaft design permits two potentiometers to be single-hole mounted for control by a dual knob. The tandem-mounted potentiometers have standard $\frac{1}{8}$ and $\frac{1}{4}$-in. shafts. The assembly is mounted by the usual $\frac{3}{8}$-in. threaded bushing or can be supplied with servo-style mounting. Waters Mfg., Inc., P.O. Box 368, S. Sudbury, Mass.

For more information—
Circle 10, inside back cover

Lead-filled Thermoplastic

This lead-filled polyethylene produces a homogeneous casting suitable for use in radioactive shielding, or as a high density molding compound. It is a compound of 95 per cent lead by weight and 5 percent polyethylene, and has a specific gravity of 7 g per cc. The mixture is melted at a temperature of 220 F into a low viscosity liquid. Telectro Industries Corp., 35-18 37 St., Long Island City 1, N.Y.

For more information—
Circle 11, inside back cover

Direct-Drive Fan Motors

The three available models are rated for 950, 775 and 625 rpm and are designed for vertical or horizontal operation. They are offered complete

with aluminum pressure-type blades and mounting components. Power ratings for the three motors are: 1/12, $\frac{1}{8}$, $\frac{1}{4}$ hp. All are designed for an input of 230 v. Electric Motors and Specialties, Inc., 101 King St., Garrett, Ind.

For more information—
Circle 12, inside back cover

Synchronous Switch

This device is used primarily in applications where the starting point is carefully set and infrequently changed. The "operate" point of the switch is adjustable in 5 deg steps by resetting the cam. Four types of interchangeable cams are available to vary switching functions. Fine adjustment is made by means of an eccentric screw that adjusts gap between distributor points.

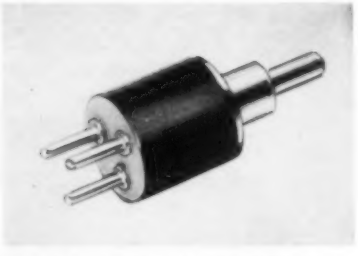
Overall size is $4\frac{13}{32}$ x $3\frac{1}{2}$ x $3\frac{7}{16}$ in. high. Farmer Electric Products Co., Inc., 2300 Washington St., Newton Lower Falls, Mass.

For more information—
Circle 13, inside back cover

Epoxy-Impregnated Glass Cloth

This material has been produced primarily for such electrical and electronic laminates as in printed circuits. It is furnished in dry, non-tacky tape or full-width rolls. Standard Insulation Co., E. Rutherford, N. J.

For more information—
Circle 14, inside back cover



Plug-in Potentiometers

The potentiometer is provided with a three-prong base that fits standard three-circuit microphone sockets. It is available in resistance ranges of 10 to 100,000 ohm, with standard accuracy of 5 per cent below 50 k and 2 per cent above 50k. Waters Mfg. Inc., P.O. Box 368, S. Sudbury, Mass.

For more information—
Circle 15, inside back cover

Remote Positioning System

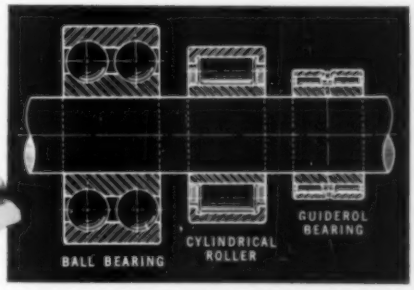
A remote positioning system for transmitting motion with appropriate output power is composed of three basic components: a transmitter, amplifier, and receiver. It is said never to allow an undesired signal to move the output shaft. Any form of motion can be transmitted or received, either linear or rotary. Power supplies of

CONTINUED ON PAGE 224

BEARING TIPS by McGill

To pack more performance in smaller space

Use space-saving McGILL GUIDEROL® needle bearings

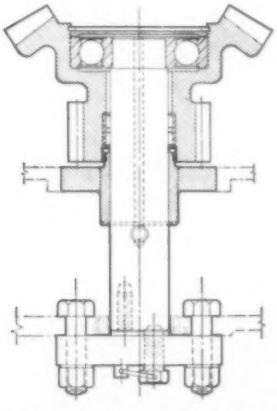


Showing graphically how a McGill GUIDEROL precision needle bearing permits more streamlined designing by supporting comparative loads in significantly smaller radial space than other types of bearings. Bulky and more costly housing space is easily avoided.

The McGill GUIDEROL Bearing combines the inherent high-load capacity of a full complement of full race width rollers with a center roller guiding principle that limits skewing and binding under misalignment. This qualifies the bearing for a whole range of applications that are too heavily loaded for a retainer-type bearing and are subject to the misalignment that precludes use of an ordinary needle bearing. For outstanding performance in small radial space, use GUIDEROL precision needle bearings. Specify the interchangeable sealed SGR series for added protection against contamination.

GUIDEROL® *bearing capacity, space economy proved in power shovel vertical reversing shaft assembly*

Baldwin - Lima - Hamilton Corp. uses a McGill GUIDEROL bearing, on ½ cubic yard power



shovels, to carry spur pinion loads in the vertical reversing shaft. The high capacity of the bearing in small radial space is an important factor in selection of this bearing. Only 3.75" in diameter, it has a load capacity of 28,560 lbs. at 100 rpm. In the power shovel application, it supports 14,150 lbs. at 76.3 rpm, which gives a high margin of safety. The center guided rollers also are especially adaptable to a vertical application such as this.

Fact-packed Bearing Catalog

Write for your copy of Catalog #52-A, a 128 page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.

Multiple spindle drill heads require support of spindles on very close centers

Crowding a great number of drill spindles into a small area, Zagar, Inc., of Cleveland has found the McGill GUIDEROL bearing construction especially suited to the needs of multiple drill head units. The full bearing width rollers provide rigidity and more than adequate load capacity and in a bearing only 1.25" in bore diameter.

Insure performance with McGILL®

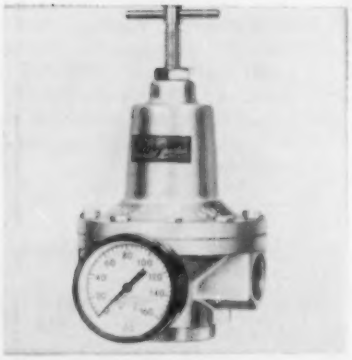
MULTIROL® GUIDEROL® CAMROL
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

amplifier and receiver need not be identical; amplifier requires 115 v, 400 cps supply, but the receiver motor may operate on practically any power supply available. Input-output ratio can be 1:1 or any other desired ratio.

Applications for the new systems include such operations as fuel mixture and throttle control on engine test cells, valve operation in process work, and remote manipulation in radioactive or hazardous locations. Bristol Co., Waterbury 20, Conn.

For more information—
Circle 16, inside back cover



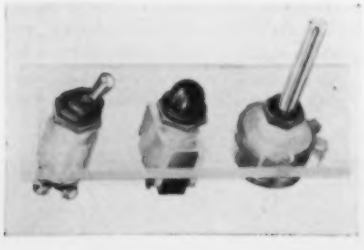
Pressure Regulator

The regulators are designed for use with water, oil and non-corrosive gases. They are available in pipe sizes ¼ through 1 in. Both relieving and non-relieving types are available. C. A. Norgren Co., 3400 S. Elati St., Englewood, Colo.

For more information—
Circle 17, inside back cover

Switch and Shaft Seals

These rubber boots fit over standard pushbutton, toggle and rotary switches to help keep dust, moisture, vapors or other contaminants from penetrating into the switch. When installed, they replace standard panel-mounting hardware on all three types of switches. A range of sizes, colors and special threads are available. Automatic & Precision Mfg. Co., 252 Hawthorne Ave., Yonkers, N. Y.

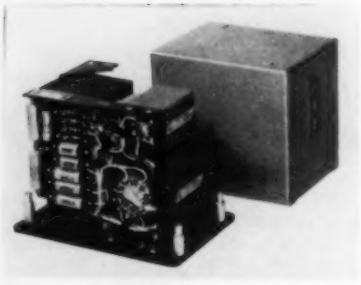


For more information—
Circle 18, inside back cover

Miniature Thermostat

This temperature control is ¼ x 1 in. long. Also available is a line of switches with various mountings. The rated load is 1 amp, 110 v a-c. These standard operating ranges are available: 50 to 175 F, 150 to 275 F, 250 to 275 F. Scaico Controls Inc., Palmyra, N. J.

For more information—
Circle 19, inside back cover



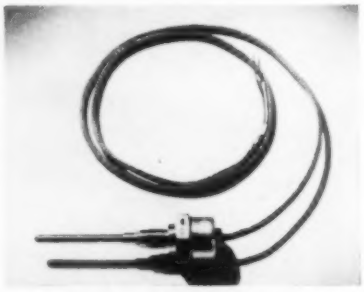
Servo Amplifiers

This line of servo amplifiers for both 60 and 400 cps servo motors ranges from 1 to 50 w. Circuit techniques range from vacuum tube to transistor-magnetic, and all the most widely used servo motors are covered. Industrial Control Co., Wyandanch, N. Y.

For more information—
Circle 20, inside back cover

Temperature Pick-Ups

Stainless steel bulb temperature pickups are high-speed resistance thermometers having an output up to 5 v without amplification. The temperature interval over which the 100 ohm resistance change will occur may



be as low as 100 F. Accuracy is dependable under 25G to 2000 cps vibration. Available in various ranges from −300 F to 1800 F, these pickups are designed to withstand pressure up to 3,000 psi. Their leads can be exposed to temperature up to 600 F and may be detached from the instrument proper for shortening or easy replacement. Accuracy is ±1 per cent of full scale. Trans-Sonics, Inc., Box 328, Lexington 73, Mass.

For more information—
Circle 21, inside back cover

Experimental Stainless Springs

Experimental stainless steel springs in both open and closed wound types for development and research work are immediately available from stock in five outside diameters and five wire sizes, ranging from $\frac{3}{32}$ to $\frac{3}{8}$ in. OD, wire diameters of 0.016 to 0.040 in. and lengths of 1¼ to 4 in. Pic Design Corp., 477 Atlantic Ave., E. Rockaway, N. Y.

For more information—
Circle 22, inside back cover

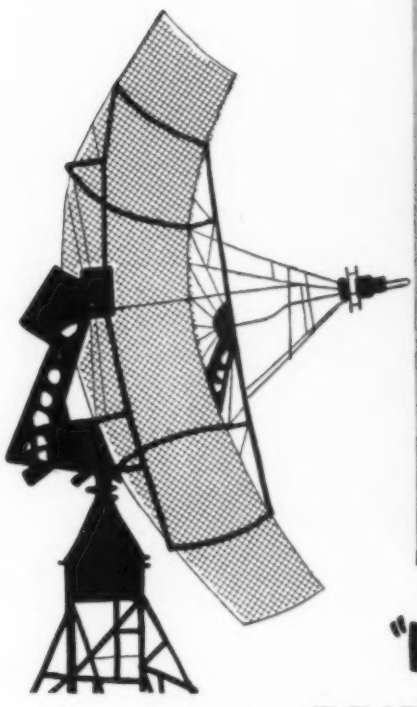
Enclosed Limit Switch

Interchangeable components, three actuators and three housings form 16 types of switches. Die-cast aluminum housings provide enclosures. Actuators include a plunger, roller arm and roller plunger types.

The roller arm actuator has a micrometer screw adjustment which moves the arm through a wide arc in setting the trip point. When the switch trips, a slight additional turn is given to allow for overtravel, then the locknut is

CONTINUED ON PAGE 226

EIMAC electron-power tube components machined and formed from Bridgeport High I.Q.* Alloys by Eitel-McCullough, Inc., San Bruno, California.



"Heart" of a RADAR system...

Depends on BRIDGEPORT HIGH I. Q.* ALLOYS

RADAR (for RAdio Detection And Ranging) is the invisible 24-hour sentry that guards the borders of North America. Day and night, a far-flung network of radar ground stations and interceptor squadrons tracks and identifies all approaching aircraft.

Heart of a radar system is the electron tube which transmits and receives microwave signals. And Bridgeport is a major supplier of oxygen-free copper alloys used in electron-power tubes.

Tubes using Bridgeport alloys are also important in the transmission of commercial television and FM broadcasting, navigation systems for civil and military aircraft, and many other electronic uses.

Production of electron-power tubes is only one example of how top efficiency is obtained when Bridgeport matches the metal to the job. Whatever your production requirements, Bridgeport's Technical Service and laboratories are always ready to assist you in material specifications. For high-quality brass and other copper alloys—alloys matched to your job—write or phone your nearest Bridgeport Sales Office.

Bridgeport's COPPER ALLOY BULLETIN contains helpful, up-to-the-minute information on metals and metal working. Are you receiving it regularly? If not, write and request your copy.

**High Inner Quality*

Bridgeport BRASS CO.

BRIDGEPORT BRASS

Offices in Principal Cities • Conveniently Located Warehouses

Bridgeport Brass Company, Bridgeport 2, Connecticut • In Canada: Noranda Copper and Brass Limited, Montreal

tightened. This way of setting the trip eliminates the trial and error method, prevents borderline operations and offers an unlimited number of trip positions. The roller arm can be turned to take positive and direct actuation from any direction. The roller plunger type actuator is adjustable through 360 deg to take actuation from any direction also. Licon Switch & Control Div. Illinois Tool Works, 2501 N. Keeler Ave., Chicago 39, Ill.

For more information—
Circle 23, inside back cover

Sub-Miniature Time Delay Relay

With an overall size of 1 1/8 x 0.750 in. dia, this relay has a contact rating of 3 amp at 115 v a-c non-inductive or 3 amp at 28 v d-c, non-inductive. Contact position is normally open, single-pole, single-throw. Operation in ambient temperatures from −65 C to 125 C is possible, and timing range is from 3 to 120 sec, ±10 per cent. Belltron Mfg. Co., 450 Hoover Ave., Bloomfield, N. J.

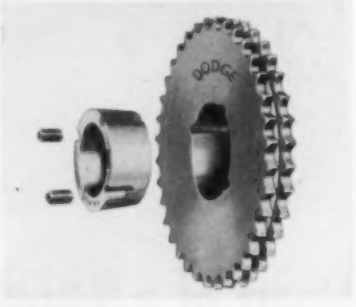
For more information—
Circle 24, inside back cover

High Voltage Combination Motor Starters

A line of high voltage combination starters for squirrel-cage, wound rotor and synchronous motors is said to provide increased overload and short circuit protection. These starters provide the advantages of current-limiting, high-interrupting-capacity fuses with rugged air brake contactors.

Design includes steel-enclosed fuse compartment; individual fuse isolation by full depth phase barriers; electrical series door interlock with automatic circuit opener; removable contact barrier with assembly access from front or rear; and insured compartment separation through flanged door housings. These starters are suitable for control and protection of all types of three-phase, 50-60 cps a-c motors operated at 2300-4800 v with the following ratings: 900 hp, unity power factor, 2300 v; 700 hp, 0.8 power factor, 4800 v. Interrupting ratings are: 150,000 kva at 2300 v and 250,000 kva at 4160-4600 v. Federal Pacific Electric Co., 888 N. Keyser Ave., Scranton, Pa.

For more information—
Circle 25, inside back cover



Double-Strand Sprockets

Double-strand roller chain sprockets require no reboring or other machining for installation on shafts. Available in pitch sizes from ½ to 1 in. Dodge Mfg. Corp., Mishawaka, Ind.

For more information—
Circle 26, inside back cover

Conveyor Belt for Small Pulleys

Combining the flexibility of solid woven belting with the superior strength and low elongation characteristics of stitched canvas, this is designed for general purpose conveying over pulleys or end rolls as small as 3½ in. dia or less. This belt is sewn on ¼-in. centers and is inner-stitched on ¼-in. centers. The belt can be used on either side as desired.

Currently available in three and four plies in a variety of widths, the belt can be supplied in any normal length required, and can be impregnated or coated with any normal treatment for stitched canvas or solid woven belting. Main Belting Co., Div. Russell Mfg. Co., 228 E. Main St., Middletown, Conn.

For more information—
Circle 27, inside back cover

Subminiature Potentiometer Trimmers

Resistance range of these wirewound trimmers has been increased to cover 10 to 150,000 ohms, with a

standard linearity of ±3 per cent. Weighing ¼ oz and ½ in. dia, ambient temperature range is −55 C to 125 C; power rating is 2 w for 60 C rise. Ace Electronics Associates, Inc., 103 Dover St., Somerville 44, Mass.

For more information—
Circle 28, inside back cover

Servo Amplifier

This is a miniaturized, hermetically-sealed, plug-in transistorized servo amplifier. It is primarily intended to

CONTINUED ON PAGE 228

"Your company will go all-out to give the best possible service"

These are the words of Fred O. Reedy, president of Kennedy-Van Saun Mfg. & Engineering Corporation, Danville, Pa. He was writing about two seamless steel rings his company required to complete a huge rotary cooler.

The larger of the two rings called for an outside diameter of 109½ in.; the other for one only slightly smaller. We forged them of special-analysis steel made in our own plant, rolled them to shape, quenched and tempered them for the right hardness and other physical characteristics—then finish-machined them to close tolerances—*and got them to our customer on time.*

The compliments from Mr. Reedy are among hundreds along the same lines in our files. We can be proud of the products we manufacture and the good service we provide—service we believe not many mills can match.

Write Dept. 4B today for the story on special-order rings, flanges and open-die forgings by Standard Steel.

"When our Purchasing Department explained the importance of this emergency job and stated how badly we needed these forged steel rings, you agreed to supplythem in 2 weeks' time and your shipment was right on schedule."

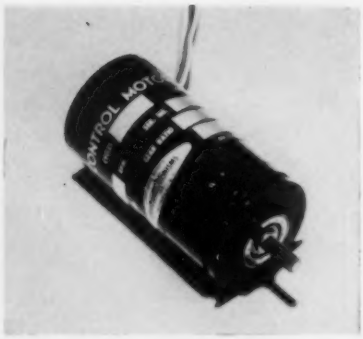
Standard Steel Works Division

BALDWIN · LIMA · HAMILTON

BURNHAM, PENNSYLVANIA Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

receive signals from a synchro control transformer and to operate a Size 15, 60 cps, 6.1 w servo motor or equivalent. The amplifier is designed to meet the environmental requirements of MIL-E-5400. Size is 1 $\frac{7}{16}$ x 1 $\frac{1}{16}$ x 3 $\frac{13}{16}$ in. high. Weight is 6 oz. M. Ten Bosch, Inc., Pleasantville, N. Y.

For more information—
Circle 29, inside back cover



Motor-Gearhead Clutch

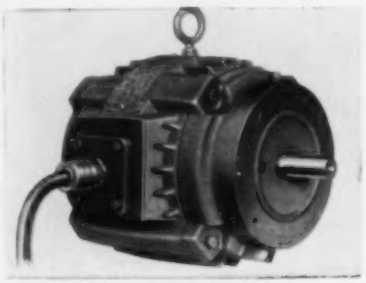
A miniature motor-gearhead-clutch 0.938 in. dia, with a maximum length of 1 $\frac{3}{4}$ in. and designed to operate directly from either a 115 or a 26-v line. This 400 cps servo unit has motor and gearhead enclosed in a common aluminum housing. Mechatrol Div., Servomechanisms, Inc., 625 Main St., Westbury, N. Y.

For more information—
Circle 30, inside back cover

Air-Over A-c Motors

A line of totally-enclosed, a-c motors produces varying horsepower according to the application of varying air velocities. This effect is accomplished by the cooling effect of the air flow over the motor frame created by the fan or blower it powers. Power output can thereby be increased without exceeding the rated temperature rise of the motor.

The motors are available in the NEMA frame sizes, $\frac{1}{2}$ through 30 hp, and may be operated on 208 v network systems. Normally supplied in non-ventilated construction, explosion-proof Class I, Group D and Class II, Groups E, F, and G enclosures are



also available. Reliance Electric & Engineering Co., 1088 Ivanhoe Road, Cleveland 10, Ohio.

For more information—
Circle 31, inside back cover

Polyurethane Foam Rubber

Available in a wide range of colors, this material is available in continuous length rolls of various sizes, die cut to specifications or fabricated in many shapes and forms. The pressure sensitive coating requires only removal of the protective paper backing. Durable Rubber Products, 609 W. Lake St., Chicago, Ill.

For more information—
Circle 32, inside back cover

Time Delay Relay

An electronic time delay relay requiring no warm-up and consuming as little as 1 w is available. Cold cathode tubes unaffected by vibration are employed to provide delays down to 3 millisec, up to 30 sec. This timer is 2 x 2 $\frac{1}{4}$ x 3 $\frac{1}{8}$ in. and weighs 9 oz. G. C. Wilson & Co., 1915-8 Ave., Huntington, W. Va.

For more information—
Circle 33, inside back cover

Direct-Indicating Frequency Meters

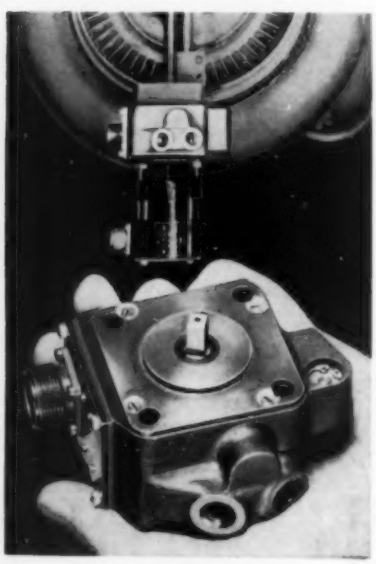
These frequency meters can be made for any frequency from 40 to 10,000 cps. Accuracy is 0.25 per cent of center scale reading and meters are available for any input voltage between 80 and 500 v. Current consumption is 2 to 4 ma. Gary Wells Co., 3 Park Row, New York 38, N. Y.

For more information—
Circle 34, inside back cover

Speed Governor and Tachometer Switch

The unit has been designed for a direct-through drive, making it possible to mount a tachometer on the governor. This makes it possible to install the governor on any engine which now has a tachometer pad.

The unit is essentially a one-speed



CONTINUED ON PAGE 230

USING

DU PONT ELASTOMERS

neoprene · Hypalon®

in design

Butterfly valve with sleeve of Hypalon® gives 2 years' perfect service handling strong acids

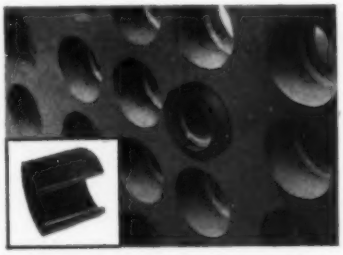
New neoprene grommet design saves $1500/yr. in material and labor costs on HCL heat exchangers

Normally, brass ferrules are used in sealing Karbate heat exchanger tubes at the tube sheet—but overtightening of the ferrules often occurs with resultant cracking of the expensive Karbate sheet. A patch is then necessary, and eventually the entire sheet must be replaced.

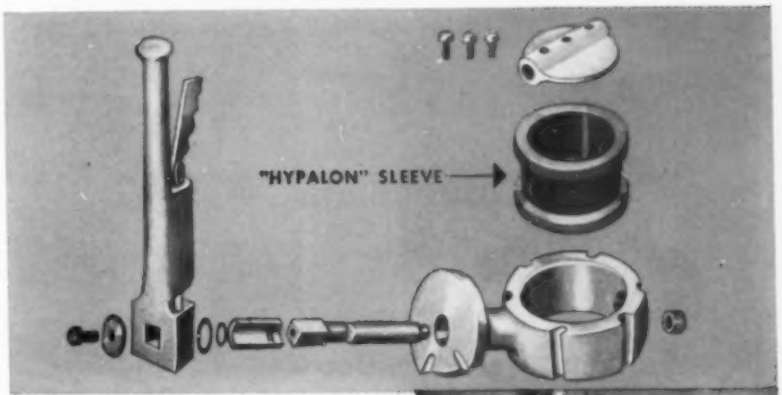
A molded neoprene seal, developed by a midwest firm, solved the problem. The seal encloses the end of the Karbate tubing and gaskets it firmly to the tube sheet. Success of the seal depends on the lasting resilience of neoprene for a cushioned, tight fit.

The firm reports 8 years of trouble-free operation with the neoprene seals—an approximate saving of $1,500 a year in material and labor. An unusual story? No. Designers everywhere are taking advantage of neoprene's resistance to acids, heat, abrasion, flex cracking, oil and grease to make better-performing products for industry.

It will pay you to get all the facts about neoprene, Du Pont's all-purpose synthetic rubber. Just mail coupon at right for full information.



NEOPRENE tube-to-tube-sheet seal is inserted with a special hand tool. Neoprene's lasting resilience assures a tight fit without damaging the Karbate, while its acid resistance gives long service.



Resilient "HYPALON" sleeve in this butterfly valve snaps into the ring piece. It acts both as a valve seat and as the gasket between the ring piece and mounting flanges, giving a perfect seal.

HYPALON's elasticity and resistance to chemicals contributes to success of valve design

Industrial Wastes, Inc., of Beaver Falls, Pa., hauls about 2½ million gallons of spent sulfuric, nitric, hydrochloric and hydrofluoric acids to their disposal plant by tank truck each month. About two years ago, the company faced the problem of finding an all-purpose tank outlet valve that would give longer service under such severe service conditions.

They tried a specially designed butterfly valve with a sleeve of HYPALON, Du Pont's new synthetic rubber. After two years of constant acid service, the valve is still in operation—an excellent example of HYPALON's chemical resistance.

Here's how the valve works: An acid-resistant metal damper rotates in a ring piece lined with a snap-in HYPALON sleeve. This resilient sleeve is slightly smaller in diameter than the metal disk, resulting in a distortion sufficient to assure a pressure-tight seal when the valve is closed.

NO OTHER RESILIENT MATERIAL can match HYPALON for service life on the "tough" jobs in industry. It has unusual resistance to hardening at elevated temperatures (250° to 350°F.) and is virtually unaffected by ozone. HYPALON also offers excellent resistance to abrasion, flame, flex cracking. We'll be glad to tell you more about HYPALON—its properties and applications. Just mail coupon below.

DU PONT

HYPALON *is a registered trademark of E. I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

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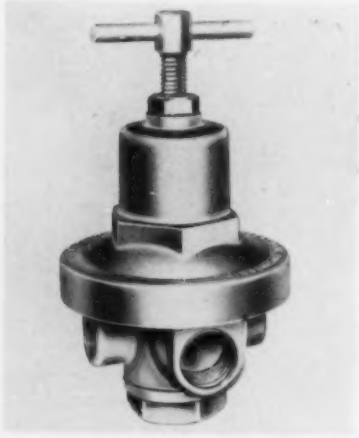
E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. PE-2
Wilmington 98, Delaware

*Name*_____
*Firm*_____
*Address*_____
*City*_____ *State*_____

governor which has been preset to cut in at a particular speed. When this speed has been reached, the governor will cut in in proportion to the increase in speed above this point. A total increase of 7 per cent of the set speed is required to reach full cut in. Lee Co., Wesley Ave., Westbrook, Conn.

For more information—
Circle 35, inside back cover



Pressure Regulators

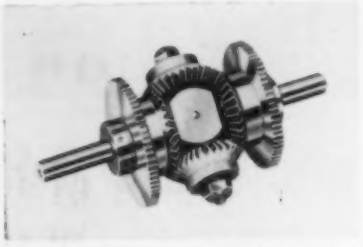
This pressure regulator for air, gasses and liquids is 2 $\frac{7}{16}$ x 3 $\frac{3}{8}$ in. high. With an inlet pressure of 200 psi and a reduced pressure of 80 psi at no-flow, the flow can be increased to 80 cfm of free air with a drop in the reduced pressure of only 2 psi. These regulators employ a direct diaphragm-operated valve. Generant Engineering Co., 260 S. 20 St., Newark 3, N. J.

For more information—
Circle 36, inside back cover

Miniature Differentials

The differentials are characterized by minimum backlash, high accuracy and low breakaway torque. They use bevel gears of the Gleason-Coniflex type, providing good tooth-to-tooth action coupled with long life. Spur input gears, as well as the bevel gears, are cut to AGMA Precision Class 2.

Three models are in stock for immediate delivery. BP-301, the largest, has a $\frac{1}{4}$ in. shaft, a breakaway torque of



0.065 in-oz, a maximum recommended maximum of 1,800 rpm. BP-310 has a $\frac{1}{8}$ in. shaft, a breakaway torque of 0.060 in-oz, a maximum recommended torque of 100 in-oz and a recommended maximum of 1,800 rpm. BP-320 has a $\frac{1}{8}$ in. shaft, a breakaway torque of 0.060 in-oz, a maximum recommended torque of 90 in-oz and a recommended maximum of 1,400 rpm. Helipot Corp., Newport Beach, Calif.

For more information—
Circle 37, inside back cover

Directional Valve

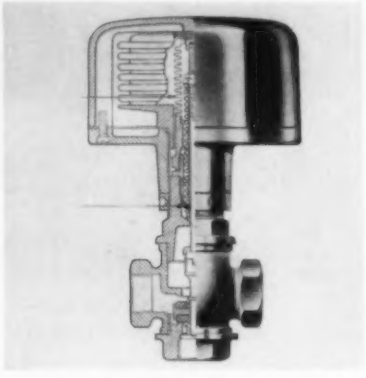
A directional valve which affords instant switch-over from automatic to manual control of diaphragm-operated valves, cylinders and similar devices is installed as a tee in the inlet line. The valve consists of a captive Hycar ball which shuttles between two seats in the Navy M bronze valve body. When pressure is applied to one port, the ball shifts to, and seals, the opposite port.

Suitable for use with air, oil, water or media compatible with Hycar and bronze, the directional valve is available with $\frac{1}{4}$ and $\frac{3}{8}$ in. ports. Net open area between seat and ball is equal to transverse area of $\frac{3}{8}$ in. standard pipe. Valvair Corp., 454 Morgan Ave., Akron 11, Ohio.

For more information—
Circle 38, inside back cover

Packless Valves

These pneumatic valves were originally designed for convectors, unit ventilators and air conditioners, and radiators. Instead of packing, they use a bronze bellows as a primary seal, and a spring-loaded neoprene O-ring



as a secondary seal. The top of the packless valve is easily removable so that the bronze bellows can be replaced without removing the valve from the line. Powers Regulator Co., 3434 Oakton St., Skokie, Ill.

For more information—
Circle 39, inside back cover

Servo for Amplifier Applications

A Size 10 servo which is less prone to single phasing and designed specifically for use with a transistorized amplifier is now available. Electrical characteristics include 115 v, fixed phase, 36 v control phase, with 3 w per phase stalled, 6,500 rpm at no-load and 0.26 in-oz. at stall minimum. Operating temperature range is −65 C to 85 C. John Oster Mfg. Co., Racine, Wis.

For more information—
Circle 40, inside back cover

Rubber Gaskets

Custom molded rubber gaskets having round cross sections as small

CONTINUED ON PAGE 232

NEW

KAYDON THIN SHELL NEEDLE BEARINGS

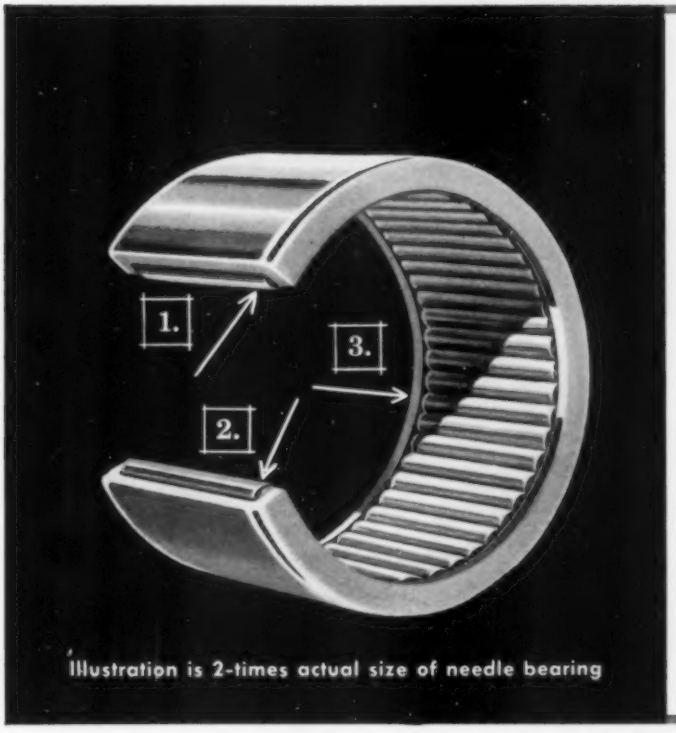
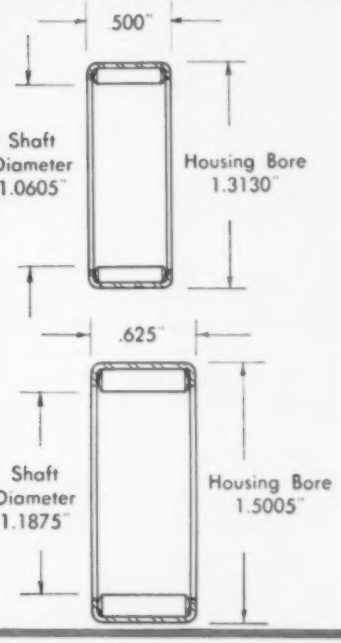


Illustration is 2-times actual size of needle bearing

Two standard sizes available from stock



You get these Kaydon design advantages:

1. Greater effective length needle rollers for MORE CAPACITY (41% on ½" width) . . . LONGER LIFE (2.8 times as much on ½" width) 2. Simplified construction that SAVES you money 3. Pre-packed lubrication that SAVES assembly time.

These new thin-shell bearings were developed with the co-operation of the FORD MOTOR COMPANY for use in FORD-O-MATIC and MERC-O-MATIC automatic transmissions

Kaydon's new thin-shell needle bearing gives more of everything — *more economy . . . more capacity . . . plus longer life* than any other comparable bearing. That's because of Kaydon's greater effective length of spherical end rollers.

This new bearing is ready for you right now from stock in two standard sizes (illustrated). Other sizes will be available later.

For complete specifications, ask for Data Sheet No. K562 — write, call or wire Kaydon of Muskegon.

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 124" outside diameter . . . Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Needle Roller • Ball Radial • Ball Thrust Bearings

as 0.020 in., varying shapes, and even mitered corners, have been produced with dimensional tolerances as close as ±0.001 in. Most natural and synthetic rubbers, including Neoprene, Buna N and silicone, can be molded to these specifications. Minnesota Rubber & Gasket Co., 3630 Wooddale Ave., Minneapolis 16, Minn.

For more information—
Circle 41, inside back cover

Resistor for Surface Temperature Indication

These resistors can be applied to any surface in a matter of seconds. There are no holes to drill. The sensing element is applied to the surface by merely pressing the thumb over a small piece of Mylar tape.

Having an output up to 5 v without amplification, these resistors can be used directly in a commutation circuit to modulate standard telemetering transmitter. These resistors are available in various ranges from −300 F to 400 F and are furnished with two 6-in. long glass-fiber-covered constantan leads. Size is ¼ x ⅛ in.; accuracy, ±2 per cent of full scale range. Trans-Sonics, Inc., Box 328, Lexington 73, Mass.

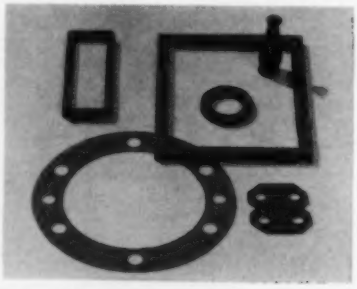
For more information—
Circle 42, inside back cover

Pressure Transducer

This transducer is designed for reliable and accurate service with a wide variety of fluids, including all jet and piston engine fuels, lubricating and hydraulic oils, and air, carbon dioxide and oxygen. Output signals may be either linear or to any desired curve, as required for actuating the appropriate control or measuring system.

The transducer will normally be available in pressure ranges of 0 to 2 psi to 0 to 250 psi, although other ranges can be supplied as required. It will be offered with potentiometer cards in resistance ranges of from 0 to 2,000 ohm, to 0 to 20,000 ohm. Current rating of a typical potentiometer is 10 ma at 5,200 ohm, although other requirements can be handled. Models with resolution of better than 0.1 per cent are available. Over-all length is 2 7/16 in., diameter 2 7/8 in.; weight is 6 oz. Bristol Co., Waterbury 20, Conn.

For more information—
Circle 43, inside back cover



Low-Durometer Silicone Rubber

A silicone rubber stock which has compresibility in the range of silicone sponge rubber is moldable in ⅛ to 1 in. sections, ⅛ to ½ in. sheets and extrudable in 10 ft. lengths. The rubber has −100 F to 500 F temperature range. Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn.

For more information—
Circle 44, inside back cover

Chassis-Mounted Terminals

According to the manufacturer, these terminals remove the need for terminal boards. They have a voltage breakdown range of up to 15 kv. Standard terminals are gold-plated to facilitate soldering. Globe Electrical Mfg. Co., 1729 W. 134 St., Gardena, Calif.

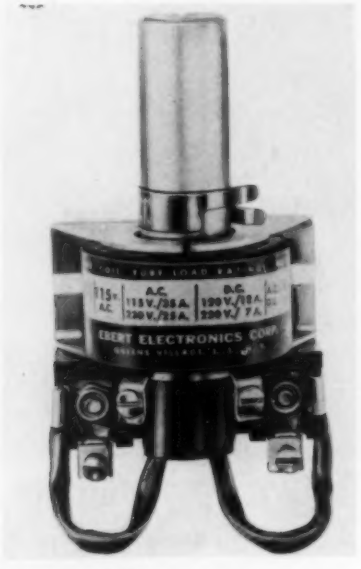
For more information—
Circle 45, inside back cover

Adjustable Flow Regulator

This regulator is for manifold mounting. Sub-plate kits are furnished with built-in check valves for free reverse flow. Minimum to maximum flow adjustments can be obtained by 180 deg movement of the control handle.

Weight is 5 lb and all exterior aluminum surfaces are anodized. Waterman Engineering Co., 725 Custer Ave., Evanston, Ill.

For more information—
Circle 46, inside back cover



Armored Relay

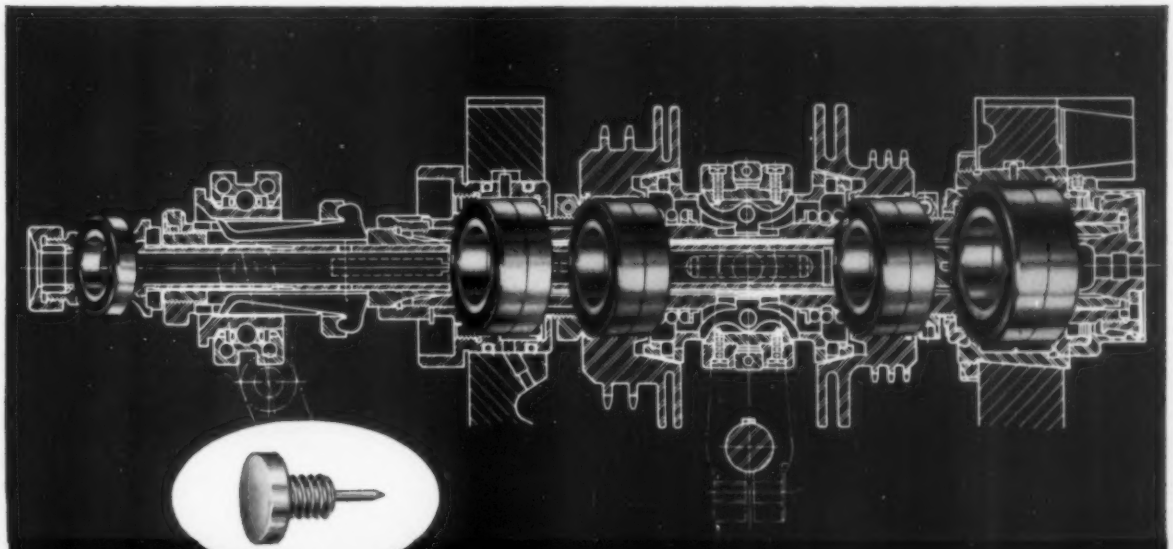
These encapsulated tube relays were designed to withstand shocks, blows and physical impact. Available in a variety of one, two and three-pole models. Ebert Electronics Corp., 212-320 Jamaica Ave., Queens Village 28, N. Y.

For more information—
Circle 47, inside back cover

Magnetic Relay

A 20-amp relay suitable for all types of fractional and integral horse-power motors is also suitable for handling solenoid valve and other control circuit relay loads for heavy motors

CONTINUED ON PAGE 234



7 seconds from nothing flat!

The brass part illustrated below the diagram is produced on the new 00 Brown & Sharpe Automatic Screw Machine in 7 seconds. That represents a 42% increase in production over the previous model.

To step up production by such a substantial percentage involved the development of new and exclusive features for the 00 machine over and above those proven so successful on the previous model. Included among them is the chain-driven, ball bearing spindle . . . see large diagram above.

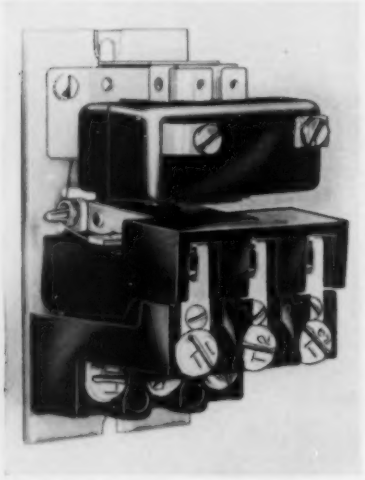
In the selection and application of the bearings for the 00 spindle, Fafnir engineers worked with Brown & Sharpe engineers. The 208 speed combinations from a high of 7200 RPM to a low of 34 RPM, permitting high cutting efficiency on a wide range of materials, presented no ordinary problem for bearings. The bearing arrangement shown meets an exacting demand for maximum radial and axial rigidity to assure true balance and running accuracy of the spindle.

Could be there's no place in your machines for these super-precision bearings. But, whenever bearings are involved, there's certainly a place in your product planning for the Fafnir "attitude and aptitude" — a way of looking at bearing problems from the designer's viewpoint plus coming up with the right bearing to fit the need. Ask your Fafnir representative for details. The Fafnir Bearing Company, New Britain, Conn.

The New Brown & Sharpe No. 00 Automatic Screw Machine with Fafnir-equipped spindle.

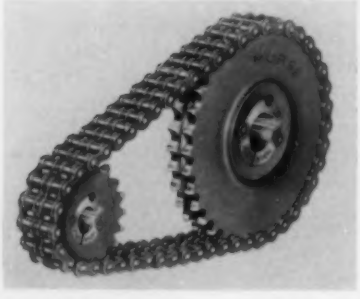
Fafnir preloaded, angular-contact, super-precision ball bearings with composition or brass retainers are made to highest industry-approved tolerances. Single or duplex bearings like this are used widely on spindle applications.

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA



and for starting and stopping small motors for power tools, fans and similar items. It is available in two, three- and four-pole arrangements, and all standard voltages. Arrow-Hart & Hegeman Electric Co., Hartford 6, Conn.

For more information—
Circle 48, inside back cover



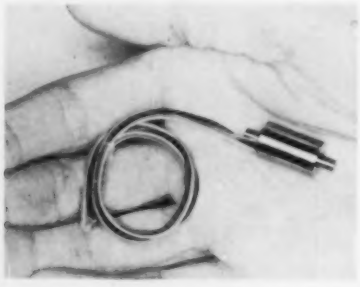
Double-Strand Roller Chain Sprocket

These sprockets are for American standard chain in ½, ⅝, ¾ and 1 in. pitches, using the taper lock hub and bushing installation method. Morse Chain Co., Ithaca, N. Y.

For more information—
Circle 49, inside back cover

Low-Range Torque Transducers

Model TF-5-0.5 has full torque range of 0.5 in-lb and Model TF 5-0.05 has full torque range of 0.05 in-lb. These



transducers operate without brushes and slip rings, with no contact between the torque shaft and the pickup housing. Crescent Engineering & Research Co., 5440 N. Peck Road, El Monte, Calif.

For more information—
Circle 50, inside back cover

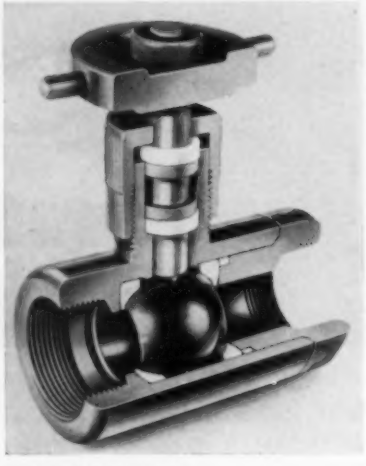
Remote Position Control

A vernier dial on the face of this control is set to establish accurately the desired position of a valve, variable speed drive control, jack or rheostat, by means of a control motor, with built-in or externally driven potentiometer. Full-scale follow-up accuracy of ±0.2 per cent is standard but multi-turn potentiometers may be used to provide accuracies of 0.04 per cent.

Depending on the speed of the control motor the follow-up control may take a minute or more or may be almost instantaneous, taking less than a second. The unit provides direct control for motors up to ⅓ hp and controls motors up to 50 hp through a reversing starter. The control may be located several thousand feet from the control motor without loss of accuracy. NEMA 1 enclosure is standard but

totally enclosed and explosionproof enclosures are available. Standard units operate on single-phase, 60 cps, 110 v. Jordan Co., Inc., 3235 W. Hampton Ave., Milwaukee 9, Wis.

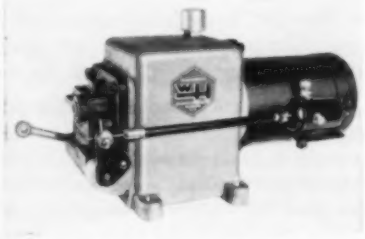
For more information—
Circle 51, inside back cover



PVC Ball Valve

Valve seats are easily replaceable. Rating is 150 psi at ambient temperatures and 50 psi at 130 F. Sizes ½ to 2 in. with screwed ends are available from stock. Jamesbury Corp., Worcester, Mass.

For more information—
Circle 52, inside back cover

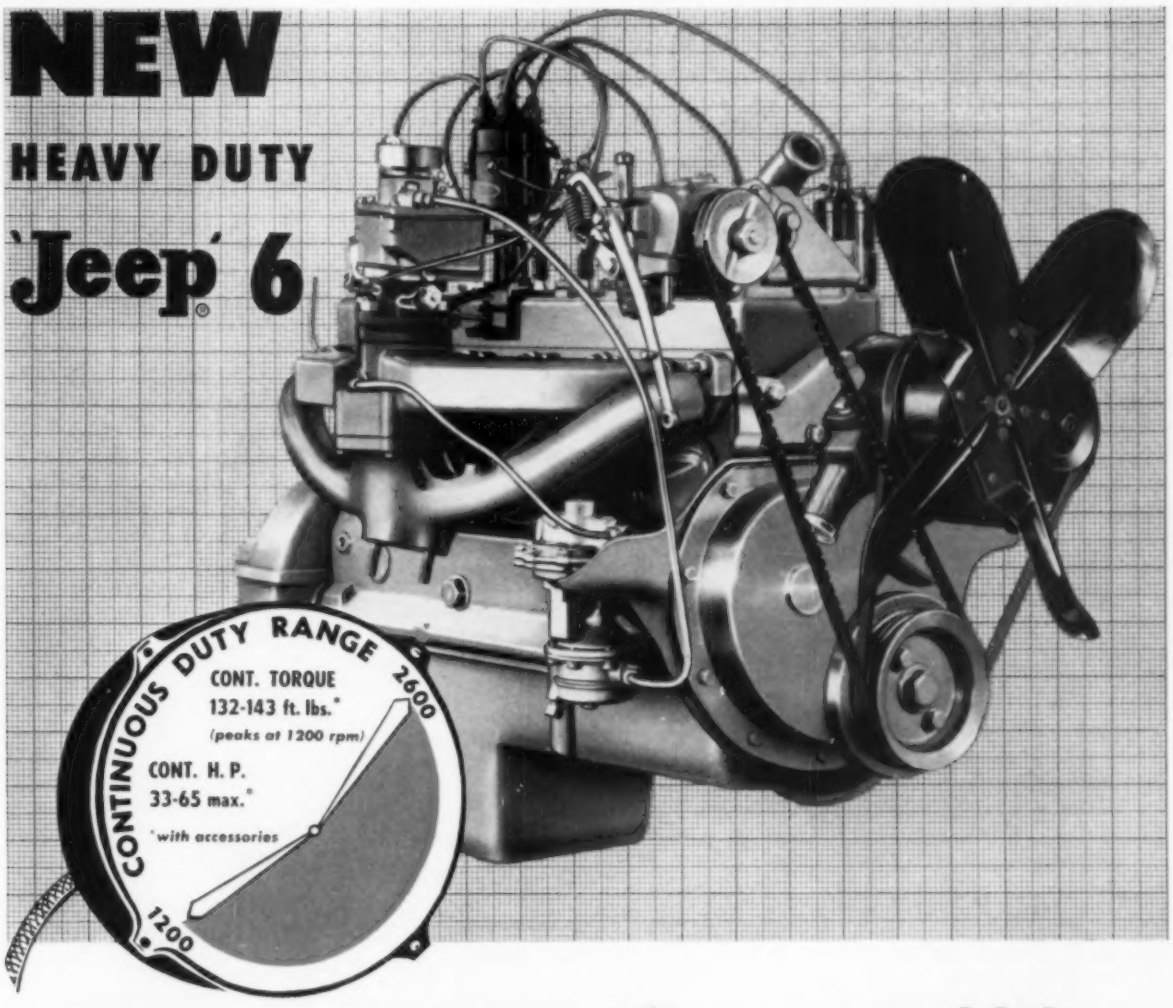


Hydraulic Power Unit

A self-contained hydraulic power unit that consists of a 6 (or 12) v d-c motor drive, pump, control valve and tank, is designed for applications on mobile equipment, snow plows, hoists, booms, tail gates. The reservoir, for 110 cu in. of oil, is made of cast aluminum. An electric motor is flange-

CONTINUED ON PAGE 236

NEW HEAVY DUTY 'Jeep' 6



HIGH TORQUE where you need it!

When your equipment meets heavy loads at low rpm . . . that's when it needs the extra lugging power provided by this new, high torque engine.

And check this for sheer ruggedness: the Heavy Duty 'Jeep'-6 was put through repeated 100 hour tests at 4,000 rpm under full load. Each test was equivalent to over 50,000 miles of normal vehicle travel. Results: *no breakdowns . . . no parts failures.*

The "Keypoint Engineered" features such as valve rotators, hard faced valves and others are standard equipment . . . for economical, dependable power at minimum first cost.

Write today for full details and prices of the new Heavy Duty 'Jeep'-6 and the famous 'Jeep'-4's.

These Keypoint Engineered Features Assure Long Engine Life, Low Upkeep

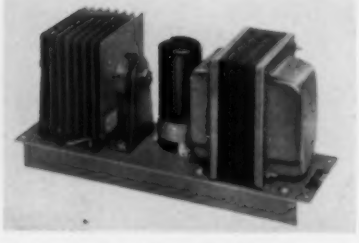
- *Positive valve rotators and Stellite or Eatonite valves.*
- *Four ring aluminum alloy pistons with hard chrome compression ring and hard chrome steel oil ring.*
- *New heavy duty bearings.*
- *100% counterweighted, forged crankshaft.*

WILLYS MOTORS, INC. ***Industrial Engine Department*** **TOLEDO, OHIO**

mounted to one end of the housing and the pump control valve to the opposite end.

All working parts are totally enclosed and permanently lubricated for complete protection from outside elements, and the one-lever control can accommodate a clevis for remote control linkage. It has three operational positions—raise, lower and spring-return to hold. Lowering control is through a throttling valve for varying the rate of return. The unit may be mounted vertically, with motor end up, or horizontally. Wisconsin Hydraulics, Inc., 3165 N. 30 St., Milwaukee 16, Wis.

For more information—
Circle 53, inside back cover



Adjustable Power Supply

A 28 v d-c, 5 amp max current is filtered for operation of relays, motors, control equipment and filaments. Output may be adjusted to 28 v d-c for various values of line and load by means of several transformer taps brought to a terminal board.

Unit is sub-chassis style, and mounts in any position. Dimensions: 12½ x 4 x 4¾ in. high above deck, 1½ in. below deck. Weight: 15 lb. Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena, Calif.

For more information—
Circle 54, inside back cover

In-Line Gage Saver

Designed for hydraulic, fuel or pneumatic systems, this unit provides automatic protection against gage overload. When the pressure drops to within gage limits again the gage is reconnected. A compression spring controls the shut-off point and may be adjusted to accommodate minor

changes. Standard units with ¼ in. male tube inlet connection and ¼ in. male tube or ¼ in. female pipe outlet connection are readily available from stock in all shut-off pressures from 60 to 3,000 psi. These units weigh approximately 2 oz are 3 in. long and have an operating temperature range of −65 F to 160 F and a maximum operating pressure of 5,000 psi. Fisher Controls Inc., 1222 7 St., Santa Monica, Calif.

For more information—
Circle 55, inside back cover

Hydraulic and Pneumatic Pressure Switch

The switch operates from 0 to 1200 psi and will withstand pressures as high as 3000 psi without distorting its pressure element. The switch is adjustable over its entire range of pressure from 0 to 1200 psi, and adjustments can be made without interfering with the pressure element.

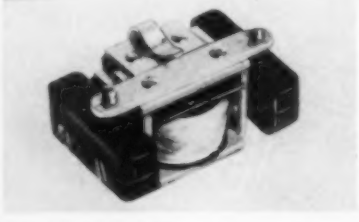
Made of cast aluminum alloy (or stainless steel), the unit is totally enclosed and weatherproof. It can use a variety of switches, at 15 amp, 120 to 460 v, a-c, with single-pole, double-throw silver contacts. Alloy Bellows Engineering Co., 18125 Roseland Road, Cleveland 12, Ohio.

For more information—
Circle 56, inside back cover

Ruggedized Meters

This instrument is a ruggedized and sealed 2½ in. round basic meter made to meet the requirements of MIL-M-6A and MIL-M-10304A. These meters are available in all standard ranges of microammeters, milliammeters, ammeters and voltmeters. Wac Line Inc., 35 S. St. Clair St., Dayton 2, Ohio.

For more information—
Circle 57, inside back cover



Sensing Relay

A precision sensing relay for aircraft component applications uses snap-action switches. It was developed as a suitable component for accurate voltage sensing with controlled differential between operate and release voltages. These relays are designed and built to specifications. Cook Electric Co., Diaphlex Div., Chicago 14, Ill.

For more information—
Circle 58, inside back cover

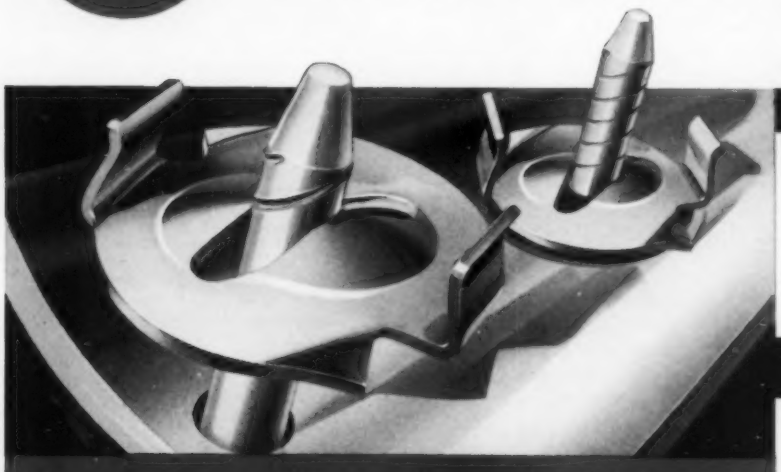
Multiple Instrument Tubing

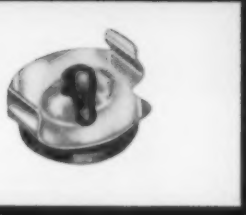
A fire and impact resistant instrument line harness is composed of a bundle of 12 polyethylene core tubes, ¼ in. OD, that are said to withstand normal instrument line pressures. Over this bundle is extruded an extra heavy thermal and shock barrier covered with braided, fireproof asbestos. The whole assembly is then covered with an extruded flame retardant outer sheath. The harness is available in increments

CONTINUED ON PAGE 238

DOT THREAD CUTTING FASTENER HOLDS TIGHT TO CURVED SURFACES

- Low Cost
- Re-Usable
- Self-Locking
- Vibration-Proof
- Spring Take-Up

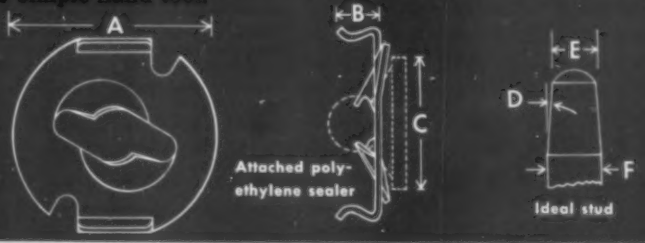




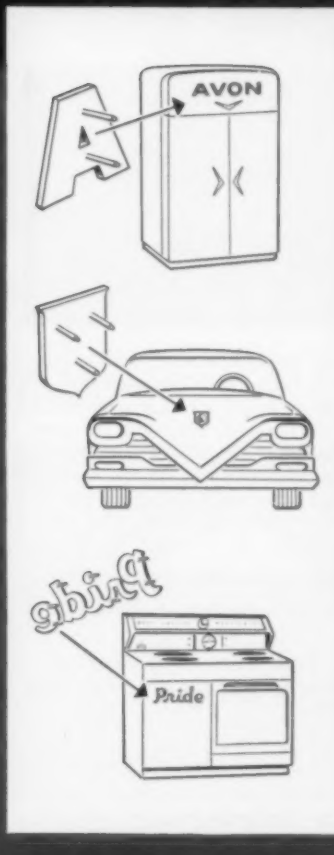
Specially designed to hold die-cast or cold-forged name plates, emblems and trim against sheet metal surfaces . . . DOT'S unique T.C.F. can be used in many other applications which require a spring take-up fastener that pulls up tight without backup on flat or contoured surfaces.

It cuts clean, deep threads on unthreaded studs, even those that are chrome plated. When used with its preassembled plastic sealer, T.C.F. makes a water-tight seal. The sealer *precedes* the fastener onto the stud so that it is not damaged by the thread-cutting process.

Available *in quantity*, with or without sealer, to fit 1/8" and 3/16" studs. Drawings available on request for magnetic tool or simple hand tool.



Nominal Sizes	A	B	C	D	E	F	Driving Torque	Ultimate Strength
1/8"	.560	.170	.450	6°/4°	.095 .085	.130 .125	7-10 Inch lbs.	200 lbs.
3/16"	.705	.200	.450	6°/3°	.160 .150	.192 .184	20 – 30 Inch lbs.	400 lbs.



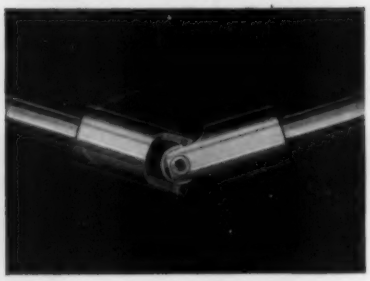
Manufactured by
MONADNOCK MILLS SUBSIDIARY
San Leandro, Cal.

DOT T.C.F.
Patent Pending

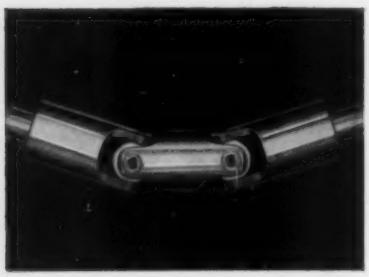
Manufactured by
CARR FASTENER CO. DIVISION
Cambridge, Mass.

UNITED-CARR FASTENER CORPORATION

How Curtis helped a design engineer "BEAT THE HEAT"



This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not ordinarily recommend angles greater than 30°.)



Curtis engineers recommended a *double* Curtis joint, which reduced the angle to 17° per joint. Result: no overheating, improved efficiency, longer life.

You can depend on Curtis engineering in any problem of angular power transmission. And you can depend on

CURTIS UNIVERSAL JOINTS

because our catalog torque and load ratings are substantiated by constant tests under production conditions.

14 SIZES ALWAYS IN STOCK —
3/8" to 4" O.D. (6" joints on special order)

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

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11 Birnie Avenue, Springfield, Mass.

As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

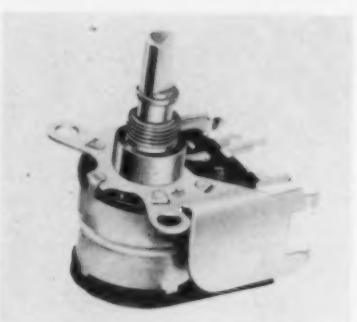
of 100 ft or in 500-ft coils. Dekoron Products Div., Samuel Moore & Co., Mantua, Ohio.

For more information—
Circle 59, inside back cover

Miniature Thermal Relays

Metal headers are bonded to glass tubing for visibility of interior in these relays, designed on the "fuse-burnout" principle. They withstand extreme conditions of temperature (−100 F to 450 F), shock (200 G), vibration (20-3000 cps). Networks Electronic Corp., 14806 Oxnard St., Van Nuys, Calif.

For more information—
Circle 60, inside back cover



Push-Pull Switch

A line switch, with push-pull action, is available on printed circuit volume controls. The switch closes the line circuit when the control shaft is pulled out, and opens the circuit when the shaft is pushed in. This action eliminates need for readjustment of volume every time the power is turned on.

(Continued on page 240)

MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES

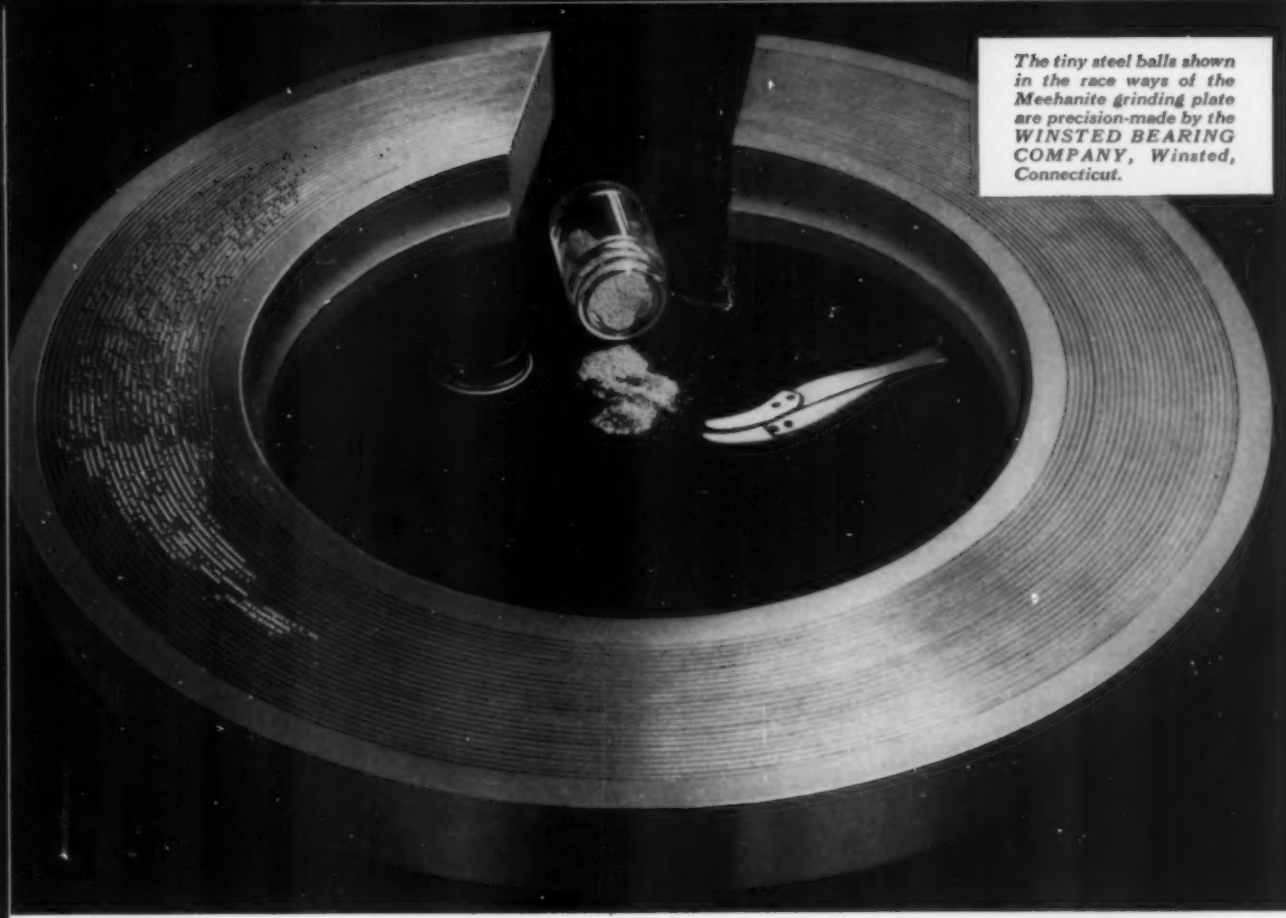
The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington, N. J.
Blackmer Pump Co., Grand Rapids, Mich.
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
DeLaval Steam Turbine Co., Trenton, N. J.
Empire Pattern & Foundry Co., Tulsa, Okla.
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundry Co., Chicago, Ill.
The Hamilton Foundry & Machine Co., Hamilton, Ohio
Hardinge Company, Inc., New York, N. Y.
Hardinge Manufacturing Co., York, Pa.
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Koehring Co., Milwaukee, Wis.
Lincoln Foundry Corp., Los Angeles, Calif.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
The Prescott Co., Menominee, Michigan
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Industries, Inc., Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Valley Iron Works, Inc., St. Paul, Minn.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

SEND FOR FREE BULLETIN

"Casting Soundness Can Be Controlled"

Write today to Meehanite Metal Corporation, Department 7G, 714 North Avenue, New Rochelle, New York.

MEEHANITE®



The tiny steel balls shown in the race ways of the Meehanite grinding plate are precision-made by the WINSTED BEARING COMPANY, Winsted, Connecticut.

Miniature steel balls are ground perfectly round on grinding plates cast in Meehanite metal

The fine grain structure and uniform solidity of Meehanite grinding plates enable the Winsted Bearing Company of Winsted, Connecticut to make miniature steel balls to the exacting requirements of the precision industries.

These exceptionally dense grinding plates, cast in quality controlled type "GA" Meehanite metal, provide long service life, maintain dimensional accuracy and can be heat treated without fear of distortion. In addition, Meehanite plates have high tensile strength (over 50,000 psi), high modulus of elasticity, low co-efficient of thermal expansion, excellent wear resistance and good machinability.

The tiny steel balls shown are used in miniature bearings, ball point pens and other precision instruments. They are made with the highest degree of uniformity and dependability. Each ball must be spherical within three to four millionths of an inch, can vary in size no more than five millionths of an inch and the surface finish must be better than half a micro-inch.

Meehanite grinding plates have been used by the Winsted Bearing Company for over six years with very satisfactory results.

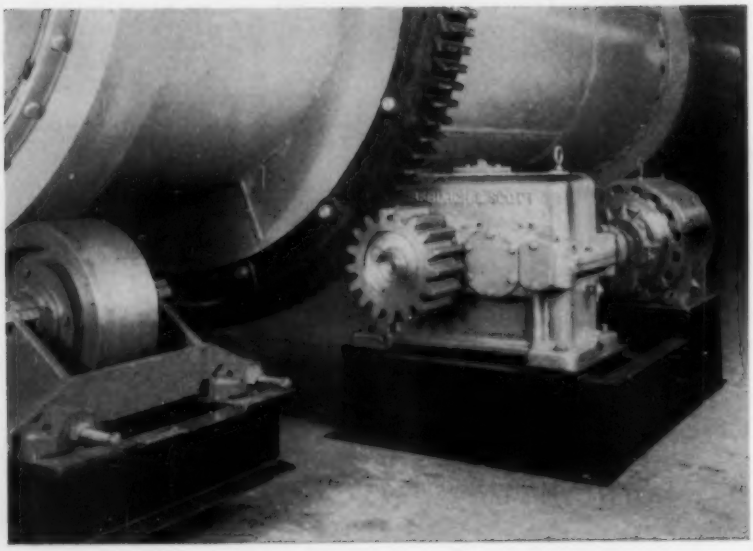
If you would like more detailed information about the physical properties of Meehanite casting, write today for Bulletin AR-130 "Casting Soundness Can Be Controlled."

Over 20,000 steel balls ground perfectly round on Meehanite grinding plates are held in the teaspoon. The hermetically sealed glass jars contain over 50,000 balls.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

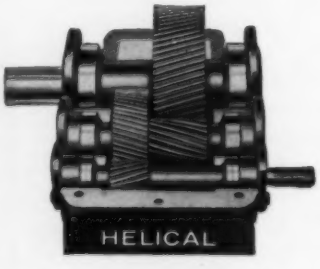


H&S speed reducer delivers 10 maintenance-free years of continuous service

Manufactured by the Louisville Drying Machinery Unit of the General American Transportation Corp., this Barite Dryer was installed in 1945. The H&S Size 2400 Speed Reducer and H&S Drive Pinion and Gears that you see above have given over 10 maintenance-free years of continuous moderate-shock service.

H&S Herringbone, Helical and Worm Gear Speed Reducers have been serving heavy industry for 26 years. If you are looking for dependable, trouble-free power transmission, won't you contact your H&S representative or write us today?

H&S Reducers are available in single reduction units in ratios up to 100 to 1; in combination units up to 700 to 1; and in double reduction units up to 10,000 to 1.



H&S Gears: There are 9 types for you to choose from! Spur Gears are cut up to 144" diameter and 1 D.P. Write today on company letterhead for the new H&S Gear Catalog No. 57.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

Types for mounting both horizontal and vertical to the printed circuit panel are available. P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind.

For more information—
Circle 61, inside back cover

Colored Toggle Switch

A toggle switch has a plastic toggle which is available in a variety of colors. Color coding of multi-circuit panel boards is readily accomplished. The switch is available in both single and double-pole and center-off types with ratings up to 20 amp and 1 hp, and carries UL-approval. It can be had with screw terminals or solder lugs, quick dismount spade-type terminals or wire leads. Carling Electric, Inc., W. Hartford, Conn.

For more information—
Circle 62, inside back cover

Subminiature Potentiometers

With a ½ in. dia, these potentiometers are available in the resistance range of 10 ohm to 250 K. Linearity is ±0.1 per cent, ambient temperature rating −55 C to 150 C. Ace Electronics Associates, Inc., 103 Dover St., Somerville 44, Mass.

For more information—
Circle 63, inside back cover

Single-Turn Potentiometers

The unit has a power rating of 5 w at 40 C, and a resistance range of 50 to 10,000 ohm, standard tolerance ±5 per cent. Standard linearity accuracy is ±0.5 per cent. Starting torque is 0.5 in-oz per section. Continuous me-

(Continued on page 242)

Illustrated—New 9700 Series Piggy Back Hydraulic Control Valve.

Look to Logan

the ultimate in hydraulic valve design

FREE SEND FOR THE "LOGAN CALCULATOR"
A gift to you from Logansport Machine Company upon request.

MEMBER: Natl. Mach. Tool Builders Assn.; Natl. Fluid Power Assn.

LOGANSPORT MACHINE CO., INC.
812 CENTER AVENUE, LOGANSPORT, INDIANA

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- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
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- ☐ 100-5-1 ULTRAMATION CYLINDERS
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- ☐ FACTS OF LIFE
- ☐ 62 SURE-FLOW PUMPS
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLINDERS
- ☐ 200-3 750 SERIES HYD. CYLINDERS
- ☐ 200-4 and 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 70-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

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COMPANY _____

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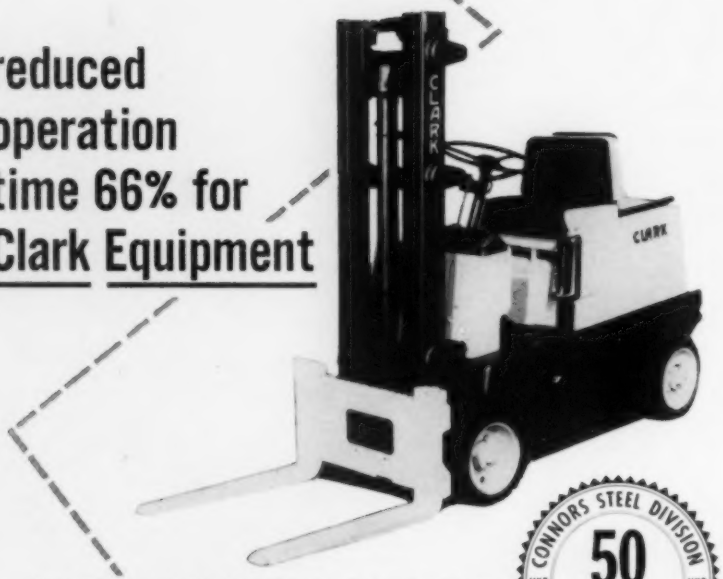
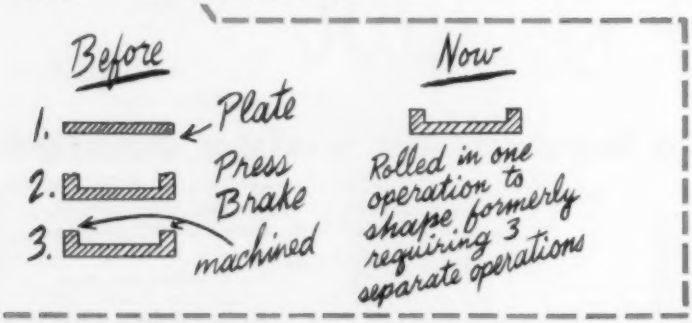
WEST VIRGINIA SPECIAL SECTIONS

reduced operation time 66% for Clark Equipment



CONNORS STEEL DIVISION
50
YEARS OF SERVICE
1907-1957
H. K. PORTER COMPANY, INC.

Clark Equipment and West Virginia engineers, working together, developed the special section used in Clark truck uprights. Clark saves time and money and West Virginia sections give ultimate strength along with economy as proved by over ten years of use.



Let West Virginia engineers help you with your problems.

Just Write or Call for ***Free Engineering Consultant Service***

West Virginia Works

HKP CONNORS STEEL DIVISION

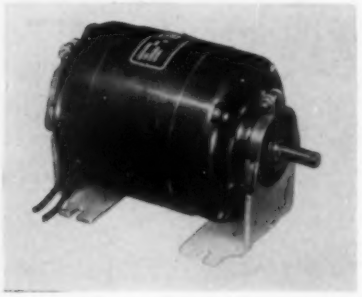
H. K. PORTER COMPANY, INC.

HUNTINGTON, WEST VIRGINIA

chanical rotation, 340 deg or less electrical rotation.

Net weight is 4 oz per single unit, with 1 oz added for each additional unit. Dimensions are 1 3/64 x 1⅞ in. Shaft is ⅜ in. long, with special lengths available. George W. Borg Corp., Janesville, Wis.

For more information—
Circle 64, inside back cover



Split-Phase Induction Motor

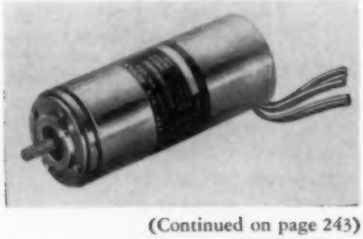
A split-phase induction motor, designed for use in office machines, blowers, pumps, coin-handling machines, has ratings of 1/20 and 1/15 hp at 1725 rpm, and 1/30 hp at 1125 rpm. Bodine Electric Co., 2254 W. Ohio St., Chicago 12, Ill.

For more information—
Circle 65, inside back cover

Tachometer Generator

A servomotor tachometer generator, with ±0.5 per cent linearity, consists of a high performance, low inertia, a-c servo motor directly coupled to an induction generator of the drag cup type. This unit is made of non-magnetic stainless steel and equipped with a precision gearhead for lower backlash. It is designed for operation in ambient temperatures up to 150 C, and is suitable for applications in instrumentation.

Among its performance characteristics are lower nulls (0.008 v rms in



(Continued on page 243)

phase; 0.015 v rms quadrature and 0.019 v rms total null) and linearity of 0.5 per cent at 3600 rpm. The unit meets Bu Ord MK-14 specifications. Eastern Air Devices, Inc., 381 Central Ave., Dover, N. H.

For more information—
Circle 66, inside back cover

Wiring Lug

The lug has a circular boss to which the insulation butts flush in full circle. There is said to be up to 11 per cent more contact area with the conductor. Serrations give higher resistance to horizontal pull. The lug is made in seven sizes. Penn-Union Electric Corp., Erie, Penna.

For more information—
Circle 67, inside back cover

Setscrews For Miniaturized Equipment

Setscrews, in socket, socket cap and slotted styles, and in a variety of points, are designed for use in miniaturized equipment such as servo-mechanisms, electronic equipment. Sizes No. 0 through 3 are available. Set Screw & Mfg. Co., Bartlett, Ill.

For more information—
Circle 68, inside back cover

Self-Locking Set Screw

Locking action is provided by an unthreaded portion of the crest, said to eliminate need for precise hole tapping. The amount of locking action can be controlled by changing the tap drill diameter. Repeated re-use does not appreciably affect the locking action. These self-locking screws are available in any size headless set screw, socket, fluted, slabbed and also slotted

(Continued on page 246)

it's "GOOD BUY"

or "GOOD-BYE" for your product

. . . there's no in-between!

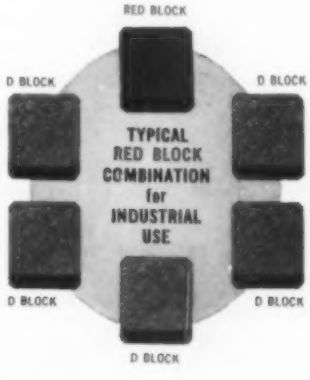
That's why the brake and clutch linings you use are important . . . because brakes and clutches are a key factor in performance, and performance is *the* main basis for judging the value of your product.

World Bestos RED BLOCK linings are the best you can use . . . best because they're the *only* linings that supply *guaranteed no-fade performance even under stepped-up operating conditions.* RED BLOCK brakes give "pinpoint" stopping power at highest operating temperatures . . . outlast other brake blocks by margins of 600% and more!

Your customer saves in reduced downtime, lower maintenance costs, higher production efficiency.

You save customers

● Write for full information and illustrated folder on RED BLOCK Combinations for industrial uses.



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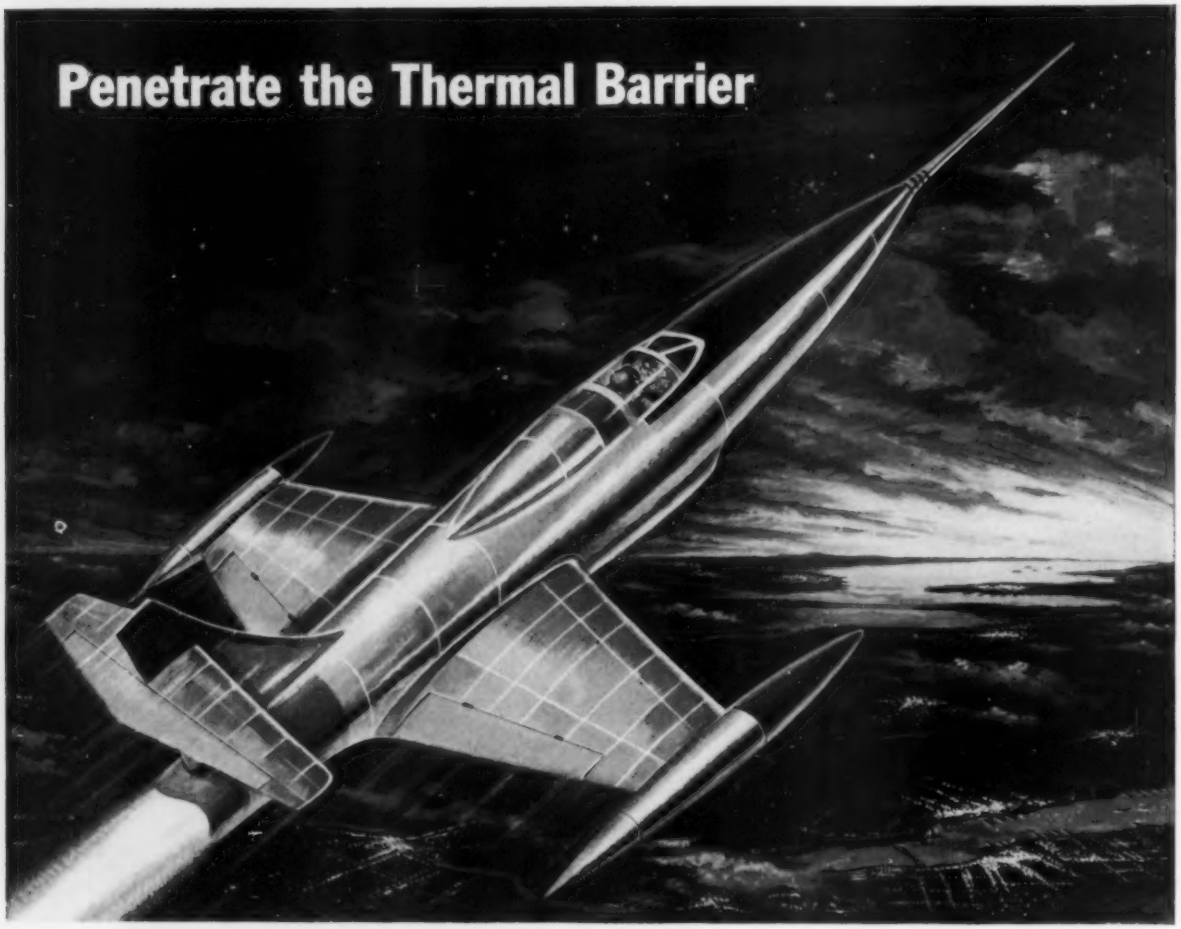
Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Clutch Facings • Vibration Controls • Sheet Packing



MicroMach extra-high-tensile stainless steel sheets up to 48″ WIDE for aircraft and missile use

As the speed of today's aircraft rapidly approaches the Thermal Barrier, conventional metals are being left far behind in the race to satisfy the structural requirements of supersonic craft. Needed are metals that can withstand the intense heat caused by air friction at high speeds and still retain their strength. One such metal, MicroMach stainless, has been in use for more than a year.

MicroMach is a special aircraft and missile grade of modified type 301 stainless steel sheet furnished to higher mechanical properties than are available in other commercial high tensile grades in the full hard condition.

These sheets are rolled to extremely close tolerances (as low as plus or minus 3%) with micro-accuracy and precise uniformity of gauge. The surface of MicroMach sheet is smooth, clean and dense; qualities so important in minimizing surface friction.

For further information write to Aircraft Steels Dept.

Washington Steel *Corporation*
2-G WOODLAND AVENUE
WASHINGTON, PA.

MicroRold stainless steel is also available in all popular grades and to meet regular government specifications. Sheets up to 36″ wide can be had as thin as .005″, and over 36″ to 48″ wide as thin as .010″ in all commercial finishes and tempers.

BIRDSBORO says:
we gained sales . . .

CLUTCHES and BRAKES...

At left is a Birdsboro 300 Ton Cold Bar Shear for cutting cold bars as they come off cooling bed of a modern alloy bar mill. The Wichita Clutch and Brake are indicated in red.

"We tried every manufacturer of air operated friction type clutches, in an effort to find one that would operate on our shears because *we were losing sales.* Wichita Clutch Engineers visited our plant and after analyzing our problem they specified the clutch application that has proved most satisfactory. We have found **WICHITA CLUTCHES AND BRAKES** practical to apply, reasonable in price and supported by good engineering service," reports the Vice-President in charge of Engineering at Birdsboro Steel Foundry and Machine Co.

Important Features

- FASTER ENGAGEMENT AND DISENGAGEMENT
- SAFER OPERATION
- COOLER RUNNING
- NO ADJUSTMENTS
- NO LUBRICATION
- EXTREMELY LONG LIFE
- EASIER MAINTENANCE
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Consult Your Nearest Wichita Engineer for Complete and Detailed Information

WICHITA Clutch COMPANY, INC.
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Smith-Keser & Co., New York, New York
Frank W. Yarline Co., Chicago, Ill.
Power Rig & Equipment Co., Inc., Long Beach, Calif.
Andrew T. Label, Denver, Colorado
Robert R. King Co., Cleveland, Ohio
John C. Burge, Oklahoma City, Okla.
Dominion Power Press Equipment, Ltd.
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Kansas City 8, Missouri

an ACCO product

Helicoid Gages

No Gears! No Teeth!

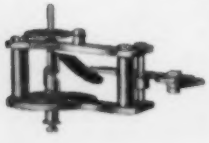
The gage of enduring accuracy

HELICOID Gages—without gears or teeth—last longer in rugged gage service because they eliminate the major sources of gage trouble. There can be no wearing and fouling of teeth or excessive play between teeth because there are no gears, no teeth in HELICOID Gages.

No expense has been spared in extensive research, engineering and testing equipment to produce this outstanding pressure instrument—a gage of the utmost precision and enduring accuracy.

HELICOID Gages are available for practically every type of installation and service—in many sizes and many styles—for pressure, vacuum or compound service. Furnished in a full range of pressures; all with the HELICOID stainless steel movement.

Write today for the HELICOID Gage Catalog



1 Stainless Steel HELICOID Roller (no gear teeth).
2 Stainless Steel Hair Spring.
3 Long Life Cam (no gear teeth).
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ACCO

Helicoid Gage Division
AMERICAN CHAIN & CABLE

929-D Connecticut Avenue • Bridgeport 2, Connecticut

for Better Value

design. Set Screw & Manufacturing Co., Bartlett, Ill.

For more information—
Circle 69, inside back cover

Flexible Couplings for Fhp Applications

Bore sizes range from $\frac{3}{16}$ to $1\frac{1}{4}$ in., diameters from $\frac{7}{8}$ to $2\frac{1}{2}$ in., lengths from $\frac{7}{8}$ to $2\frac{1}{4}$ in. Designed primarily for hp duty, the couplings consist of two durable light-weight aluminum hubs which fit into synthetic rubber molded into an aluminum center ring. Smith & Serrell, Inc., 200 Washington St., Newark, N. J.

For more information—
Circle 70, inside back cover

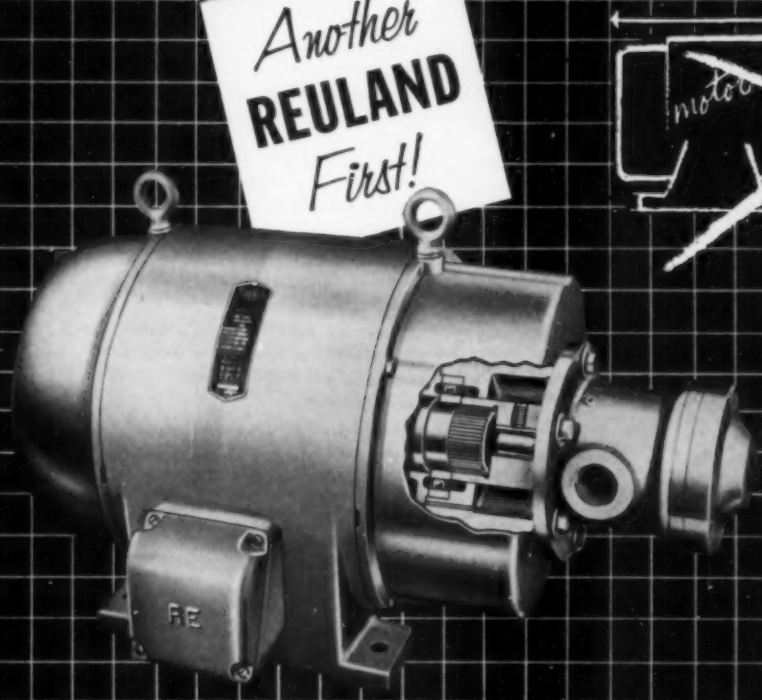
Remote Bulb Temperature Control

The complete unit consists of a bulb, capillary tube, bellows, and a control head. The bellows is attached to the control head and is connected to the remotely-located bulb by means of the capillary tube. Bulb, capillary tube, and bellows are all completely liquid-filled and incompressible. When heat is applied to the sensitive bulb, the liquid expands and causes a uniformly linear motion of the bellows plunger. The plunger operates the switches when the temperature reaches the points established by the control adjustments. The bellows is spring-loaded to insure quick, accurate response to all changes in temperature.

Temperature settings are made by rotating a single-turn knob and pointer against a calibrated scale. Models are available with range spans of 100 F or 200 F between limits of −150 F and 650 F, and with on-off differentials of approximately 1 and 2 F. An adjusting screw is attached to each switch

(Continued on page 250)

Another REULAND First!



- NO PLATFORM TO BUILD
- MUCH SHORTER LENGTH
- AUTOMATIC, PERFECT ALIGNMENT
- 30 H.P. 2½" SHORTER THAN FORMER 15 H.P. MODEL

NEW, REULAND HYDRAULIC PUMP MOTOR features FAST, SPLINE-COUPLED hook-up!

Perfect alignment ...in 1/10th ordinary time

You can hook up a Reuland motor and any standard make hydraulic pump in a matter of only seconds. All you have to do is slip the spline coupling onto the motor's spline shaft and attach the pump flange to the endbell.

Absolutely perfect alignment is assured. There is no tinkering around with a mounting platform and your finished job always has a sleek, well-designed appearance. Takes only a tiny fraction of the ordinary time.

For all standard pumps

Regardless of the pump you are now using, you can adopt this exclusive new Reuland hook-up.

If your pump is not a standard make we can quickly adapt to your setup. The Reuland method is so radically simple you will be amazed at the tremendous advantages.

Coupling supplied with motor

Buy a Reuland hydraulic pump motor and you need nothing more. Spline coupling and drilled-and-tapped endbell are supplied ready for immediate pump attachment. (Adaptable to either single or double end pump installations.)

Use these new Reuland motors and you will save platform mounting expense and alignment time. You achieve compactness and better looks *plus* longer pump life through factory engineered alignment. For FREE ENGINEERING LITERATURE please write for folder No. 1109.

Other Reuland firsts...

- MOTOR WITH INTERNAL FLUID COUPLING
- ALL-ALUMINUM MOTOR FRAMES
- "THROUGH-SHAFT" MAGNETIC DISC BRAKES
- FOOT MOUNTED MAGNETIC DISC BRAKE COMPLETE WITH BEARINGS AND SHAFT
- PRECISION MOTORS FOR MACHINE TOOLS

Don't pay for special-motor development before you check Reuland's

Special-Motor Library

Hundreds of different and unique electric motors — one of which may already be made to order for your needs. Originally designed for special uses. Now available to help you save expensive development work and put you in production faster!

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REULAND ELECTRIC COMPANY

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Distributors in all principal cities

(Advertisement)

THIRD OF A SERIES

Why reliability engineering is not enough

There's more to reliability than meets the eye ... a thousand inspectors cannot put reliability into an item that is inherently weak in engineering or production design ... highest reliability in a component is obtained only when the manufacturer is aware of the problems in obtaining reliability ... plus providing a proper climate in which employees are motivated by pride in product to surpass specifications.

In our humble opinion, the building of reliability into a product requires an alert *awareness* of the many, many facets of the problem. We'd like to submit these . . .

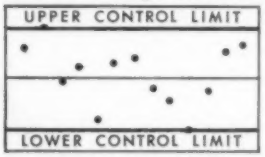
- ✱ ***"Integrity of intent" on the part of the manufacturer to meet the problems . . . coupled with provision of a proper climate for the carrying out of reliability objectives***
- ✱ ***Financial ability to take the necessary steps***
- ✱ ***Modern manufacturing equipment and methods***
- ✱ ***Plant capacity and flexibility***
- ✱ ***Design and engineering know-how that recognizes end-use requirements and environmental conditions***
- ✱ ***Careful employee selection and training***
- ✱ ***Long-range master planning***
- ✱ ***In-plant industrial and production engineering***
- ✱ ***Research, testing, development laboratory activities, including complete testing of prototype to end-use requirements***
- ✱ ***Continuous reliability assurance testing during the manufacturing operation, and institution of required corrective action***
- ✱ ***Collection, in the field, of failure data, analysis, and corrective action***
- ✱ ***All of these facets in depth***

Important as all of these are, the most important is the provision of proper climate, in the form of spirit and attitude of all personnel in pride of product, to carry out reliability objectives. In preceding articles in this series we've touched on some of the more technical aspects of reliability engineering. The manufacturer must naturally have an awareness of the problem, the integrity of intent to turn out the best product it can for a particular market or application, the financial ability to establish a Reliability program, the management ability to install it, the necessary manufacturing equipment and engineering organization to carry it out. But *all of these are not enough, if they are not instituted in a climate where an attitude will prevail that makes such things effective.*

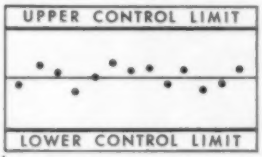
The manufacturer's integrity must necessarily be carried out, also, in the design, in manufacturing, and in finally warranting the product created . . . but, again, with every man and woman in the organization trying to meet or exceed the standards that have been created. This latter aspect we call "pride of product" on the part of the people who are producing it. And such pride must exist not only for the final product but for each part of that product, and in each step in the process. There is also an added dividend to reliability; the reputation of the product will cause the user to handle it with the same pride and care as was put into its manufacture.

It is interesting that people who are proud of a product, and enjoy what they are doing, can keep closer tolerances on the parts they work with and produce than those who are merely working for their pay. An assembler, who's proud of the product turned out, sees questionable components and avoids putting them into the assembly, while a disinterested person leaves them for "inspection" to catch. It is interesting in this connection, too, that some of the finest watch

parts made in Switzerland are produced in little shops where modern quality control techniques are unheard of . . . produced by a craftsman whose major technique is pride in his work . . . and thereby builds everything to the exacting tolerances required.



Quality control graph . . . without pride in product.



Quality control graph . . . with pride in product.

The atmosphere here at Cannon, since our inception in 1915, has included a design and manufacturing philosophy embracing the highest quality and reliability in each Cannon Plug for the specific application for which it is to be used. *To these principles all Cannon Plugs are built*! Even on connectors designed to customer or MIL-spec we constantly strive to give even more . . . to increase the safety factor . . . to give that "something extra" according to our own high "Cannon Standards", as exemplified in our Cannon Credo.

THE CANNON "CREDO"

TO DEVELOP *an organization of exceptional people possessed of respect for the dignity of the individual and imbued with the spirit of the team.*

TO PROVIDE *a facility with which we can produce to our utmost in an efficient and pleasant environment.*

TO DEVELOP *and produce products of such quality, and render such service, that we may always be proud of our efforts.*

TO MARKET *the product of our endeavor at a reasonable profit for continuing growth, reward for effort and a return on investment.*

TO ACCEPT *our responsibility to our community, our country, and our fellow man.*

The Cannon "Credo" is posted through all departments of all Cannon plants . . . Copy available to you on request.

On the more technical side . . . we at Cannon have attempted not only to provide the proper climate for a complete reliability program from the viewpoint of mental attitude, but to provide the necessary facilities in which that attitude may work effectively. One of the most important of such fields is that of engineering organization and proper utilization of specialized engineering personnel. As a purchaser of Cannon Plugs, with a personal stake in their reliability, you will be interested to know that our engineering divisions are grouped as follows:

Master Planning Group . . . men who look to the future . . . investigating the newest in technological improvements, providing interplant project coordination for maximum flexibility to meet the challenges of our ever-changing future.

Industrial Engineering Group . . . experts who call out the materials, methods, and processes to be used in the manufacturing cycle . . . experts who collect, analyze, and institute corrective action in accordance with field failure data.

Sales Engineers . . . fully qualified technical men who contact our customers.

Design Engineers . . . specialists in past and present design methods who analyze failure data caused by design inadequacies and initiate corrective action.

Development Engineering and Model Shop Group . . . specializing in the development of prototypes. In these Laboratories, your prototype is tested to see that all specifications are met . . . physical, operating, environmental. Test reports are made up, and presented to you for review and approval. Not until all these steps have been taken is your order placed in production.

Product Engineers . . . specialists in particular types of connectors.

Quality Control Group . . . well qualified to administer the high requirements of "Cannon Standards" . . . staffed by well trained inspectors and analysts equipped with the most modern equipment.

Quality Engineering Group . . . handling the technical aspects of sampling plans . . . preparing inspection and test procedures to realize the customer's desired quality level and the over-all quality level of the entire Cannon manufacturing operation. Materials are processed through receiving inspection. Process, re-work and final inspection barriers are set up. In addition to standard Military and Cannon manuals of quality control procedures, specific jobs . . . such as yours . . . may require additional special inspection or testing. If so, these requirements are established throughout the process, and where necessary, coordinated with you. Our failure data collection and analysis in this field has given us intimate knowledge of the critical points at which such control should be used. Recognized statistical control procedures are used both in process and at the inspection points.

Materials and Processes Laboratory Group . . . working in both the research and production phases. This is the group that checks performance of new designs, constantly investigates new materials and processes, and (over and above normal manufacturing supervision and quality control operation) runs continuous reliability and assurance tests on the manufacturing cycle.

* * *

Each of our 20,000 Standard Cannon Plugs are of highest quality and were designed to meet exacting reliability requirements. We also produce special designs to meet the most exceptional AQL end-use requirements.

If you have a problem requiring high-reliability Cannon Plugs, we would appreciate the opportunity working with you.

Cordially,

Robert J. Cannon *President*

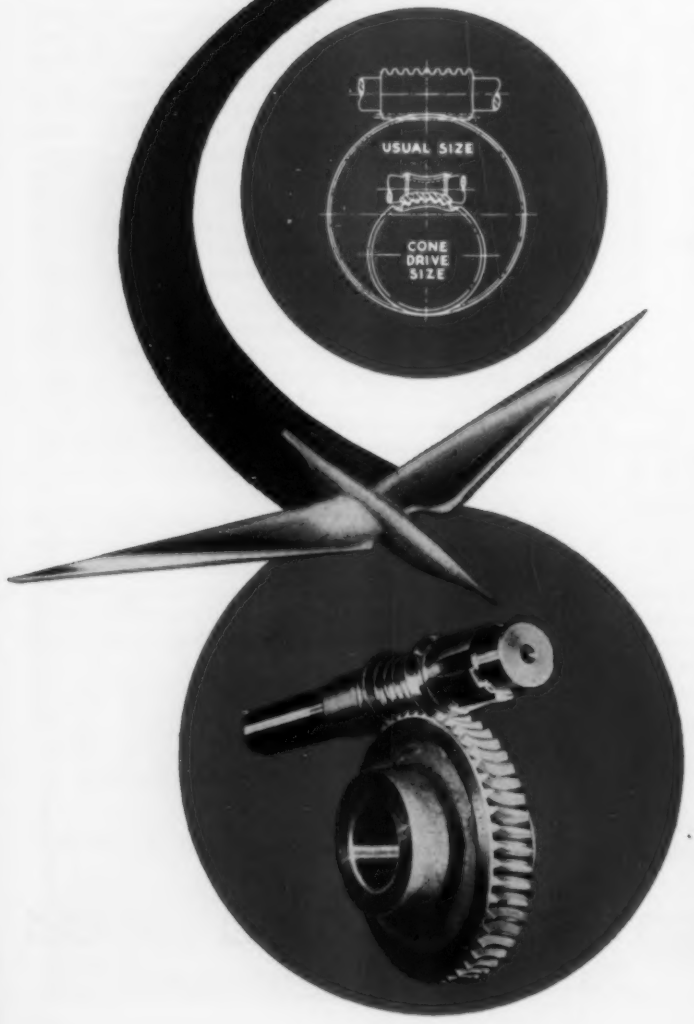
CANNON ELECTRIC COMPANY
3208 Humboldt Street, Los Angeles 31, California

Please Refer to Dept. 106

CANNON PLUGS

Eight plants around the seven seas!

for smooth power



. . . CONE-DRIVE gearing has no equal.

You can drive the most delicate equipment or the heaviest industrial machinery without vibration or noise through a set of Cone-Drive gears.

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The contact between teeth is "area" rather than the line or point type contact found in cylindrical worm gearing. This distributes the load over more area on each tooth to boost load-carrying capacity.

Want smooth, chatter-free, efficient power in a compact package? Cone-Drive gears will give it to you in gearsets or speed reducers in a wide range of models and sizes.

Ask for Bulletin 600-C for details.

CONE-DRIVE GEARS
Division, Michigan Tool Company

DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNICHOLS ROAD • DETROIT 12, MICHIGAN

so that each switch can be adjusted individually up to a maximum span of approximately 15 F between switch settings. United Electric Controls Co., 79 School St., Watertown, Mass.

For more information—
Circle 71, inside back cover

Instrument Balls

A line of precision instrument balls are available in both Type 440 stainless steel and nylon, in diameters ranging from 0.0625 to 0.2500 in. Immediate delivery from stock. Pic Design Corp., Div. Benrus Watch Co., Inc., 477 Atlantic Ave., E. Rockaway, N. Y.

For more information—
Circle 72, inside back cover

Air Line Filter

Moisture removal efficiency is said to be stepped up in these redesigned filters. Pressure drop has been further reduced. Hinged-type clamp rings have chained clamp pin simplifying servicing. Louver plates set in an improved centrifugal air flow pattern. C. A. Norgren Co., 3400 S. Elati St., Englewood, Colo.

For more information—
Circle 73, inside back cover

Core Magnet Meter Movement

The magnet design is said to assure good linearity for 100 deg of scale arc. Sensitivities as low as 20 microamp are accomplished with a coil resistance of

(Continued on page 253)

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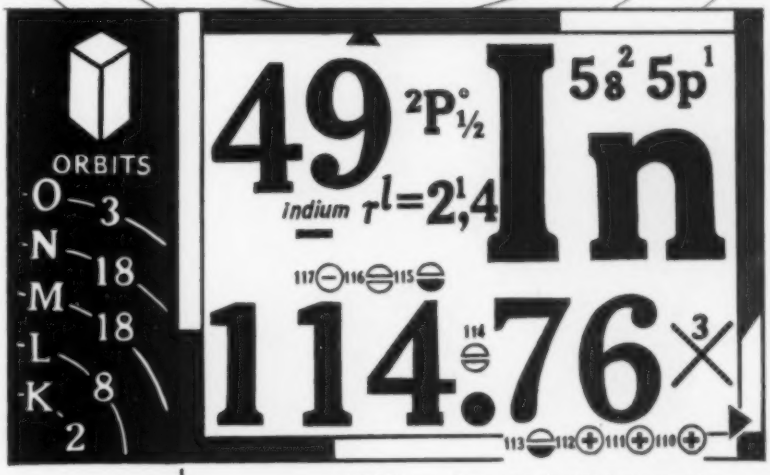

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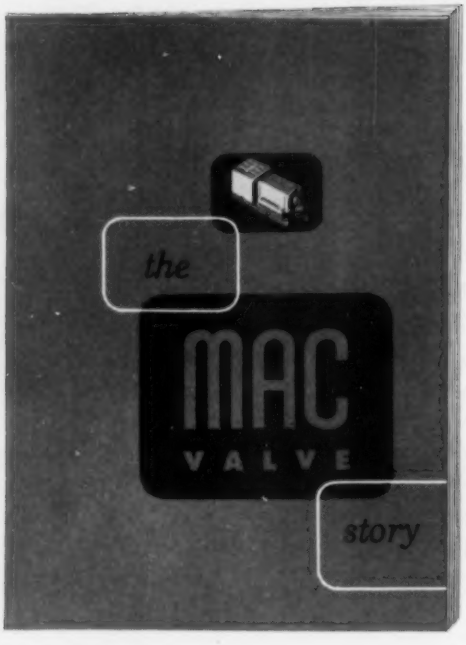
FACTS



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Form, Structure, Action

. . . about air valves!

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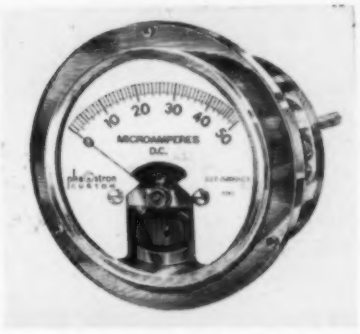
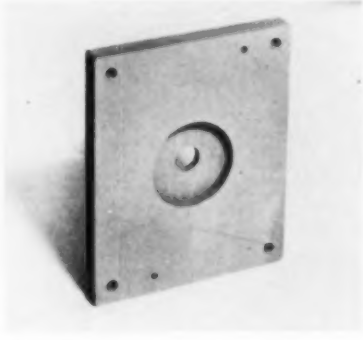


3000 ohm and better than average spring torque.

This movement is being produced at present in a 2¼ in. round, clear plastic case. Phaostron Instrument and Electronic Co., 151 Pasadena Ave., S. Pasadena, Calif.

For more information—
Circle 74, inside back cover



Servo Component Mounting Plates

A complete line of servo component mounting plates are made of 24 ST aluminum with a chromic acid anodized finish. They are designed for horizontal and vertical mounting. These plates are available for immediate delivery from stock. Pic Design Corp., Div. Benrus Watch Co., Inc., 477 Atlantic Ave., E. Rockaway, N. Y.

For more information—
Circle 75, inside back cover

Magnetic Amplifiers

These magnetic amplifier circuit components are designed for use in assembling any of the basic circuits. The units are available up to 300 w capacity.

Three basic sizes are available to

(Continued on page 256)

Special BALLS

. . in experimental and production quantities—

For

- HIGH TEMPERATURES
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. . other special requirements

ALL SIZES, standard and special, from 1/64" to 12" or more, depending on material.

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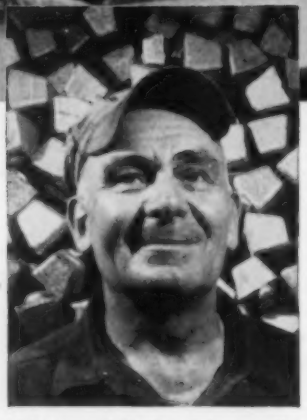
PRECISION BALLS AND SPECIAL ANTI-FRICTION BEARINGS

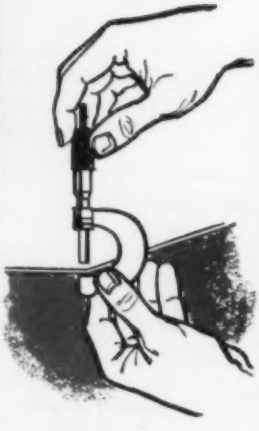
accurate!

...in gauge *and* temper!

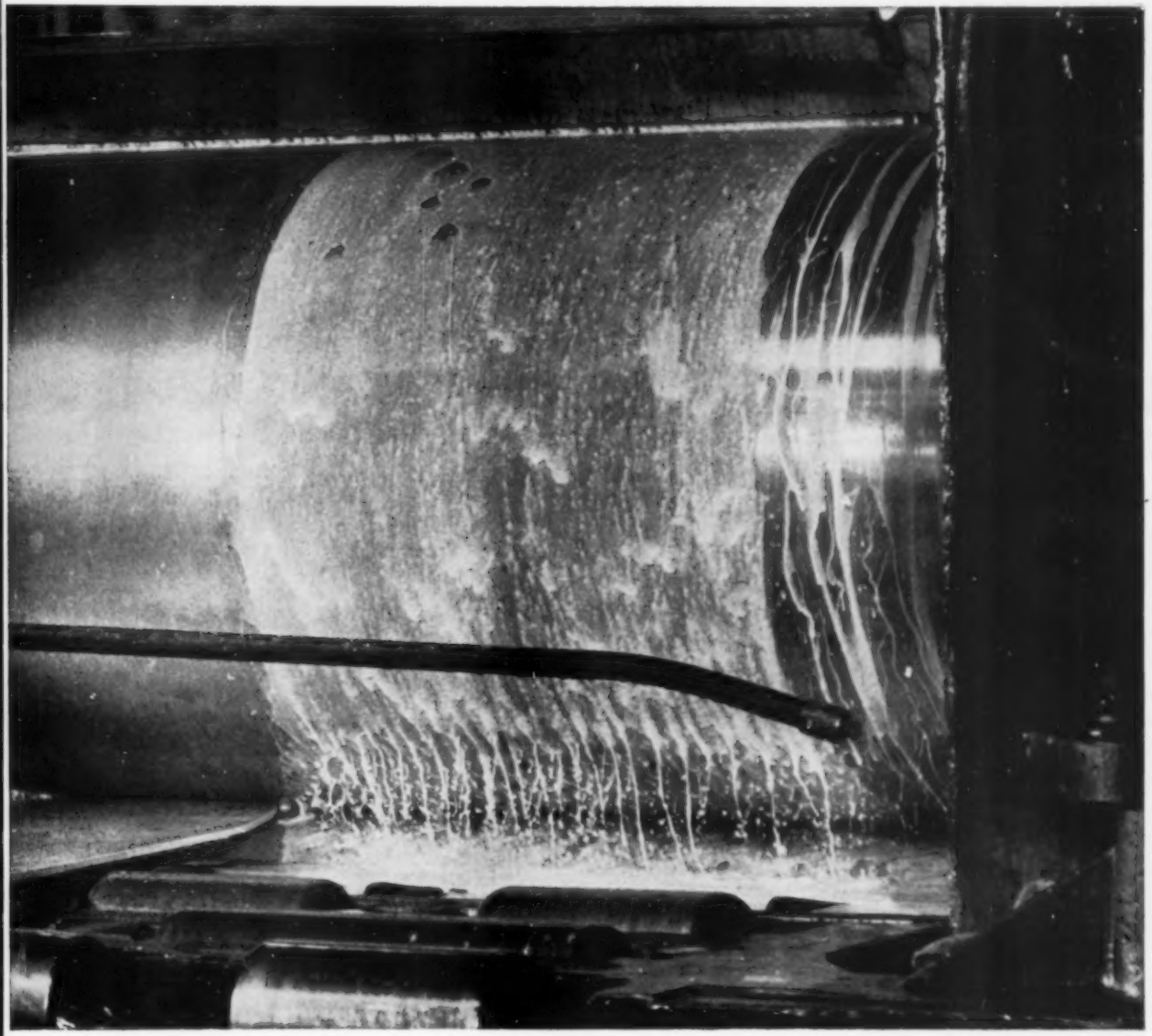


John Broehm, big boss of the breakdown rolls, has been putting pressure on aluminum for 31 years. "No matter how thick or thin you squeeze it, it's always 'the finest aluminum,'" is the way John puts it.

The pressure's



Much of the sheet aluminum used in our five large fabricating plants is produced in our *own* rolling mill. This on-the-spot control permits us to give our customers finished components made from metal of standard or special tempers and thicknesses. Aluminum sheet for parts of all sizes, from the smallest, light-gauge tube shields for portable radios to heavy-gauge deepwell cookers and 4-foot ceiling panels, is accurately controlled throughout the breakdown roll and rolling mill processes. This control of accuracy assures a minimum



on...375 tons of it!

rejection rate of the end product into which the metal is formed. Our rolling mill operation, with its entire output for exclusive use in our stamping plants, has the further advantage of speeding up production schedules, since it eliminates delays due to shipment of metal from outside sources.

If accurate operation and skilled production planning appeal to you, send us your inquiries . . . or even better, visit our plants to see how our facilities can help *you*.

ALUMINUM GOODS MANUFACTURING CO.
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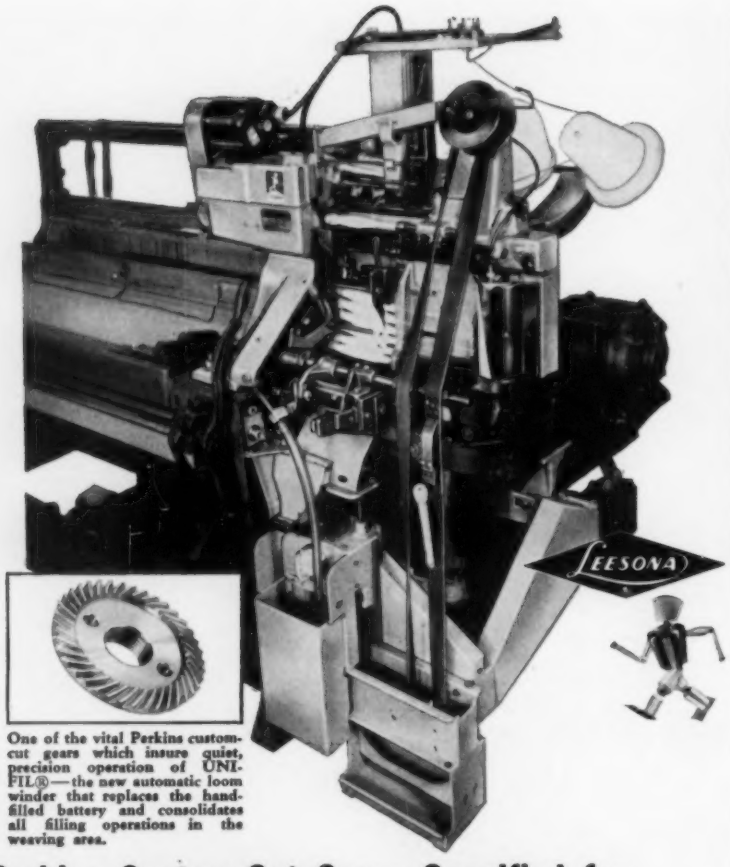


One of the vital Perkins custom-cut gears which insure quiet, precision operation of UNIFIL®—the new automatic loom winder that replaces the hand-filled battery and consolidates all filling operations in the weaving area.

Perkins Custom-Cut Gears Specified for Universal Winding's New Unifil® Loom Winder

Quality and service determine Universal Winding Company's choice of Perkins custom-cut gears for many of their machines, including the new UNIFIL®. Perkins gears are precisely cut to exact specifications which eliminate noise, wear and backlash. This means fewer rejects, lower maintenance cost and longer gear life. Extensive facilities and modern equipment, backed by 52 years of gear-making know-how insure prompt delivery, as scheduled, to meet production needs. You, too, can benefit from Perkins *quality* and *service*. Perkins can cut your gears from any material — metallic or non-metallic. If you require a special deep or shallow pitch, a gear with a hub, clutch teeth or other special features, Perkins engineers will work with you to insure efficient and economical gear design. Ask us to quote on your next gear requirement.

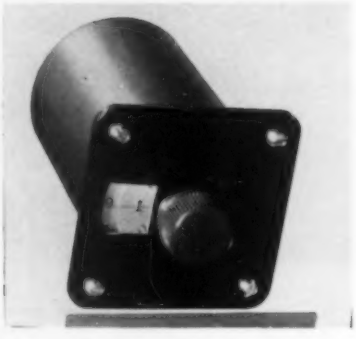
YOURS ON REQUEST — Folder illustrating gears Perkins has made — face gears, generated and curvic clutches; bevel, spiral, helical and spur gears; ratchets, sprockets and ground thread worms . . . from all materials. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

Dept.12, West Springfield, Mass.
Telephone: REpublic 7-4751

cover the range of 1.5 to 300 w, 60 and 400 cps. The largest unit, rated at 300 w at 400 cps, measures 4 1/6 x 2 7/16 in. dia. Adler Electronics, Inc., 1 LeFevre Lane, New Rochelle, N. Y.

For more information—
Circle 76, inside back cover



Four-Terminal Voltage Divider

The unit may be used as a potentiometer or rheostat. Two turns of the control knob covers the full range of the device, and resolution is said to be equal to a 10-turn potentiometer.

The complete unit mounts like a panel meter and uses 2 by 2 in. of panel space, with 2½ in. projecting behind the panel. Resistance is 10,000 ohm when used as a potentiometer and 0 to 10,000 ohm when used as a rheostat. Accuracy is 0.1 per cent of full scale. Linearity is ±0.1 per cent. Wattage is 4 w when used as a poten-

(Continued on page 260)

Design "Low Cost" Into YOUR Equipment

GITS

World's Largest Selection of Low-Cost Lubricating Devices

LUBRIKIT . . . An assortment of 95 oil cups of 29 different types. Gits sales records show these oilers are most used for replacement and maintenance. Contents of each separate bin are clearly described on Inside Cover.

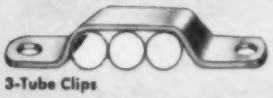
Special Introductory Price
Just **$14.95** F.O.B. Factory
Satisfaction or your money back

CLIPS FOR ATTACHING TUBING

When ordering, specify ¼", 5/16" or ⅜" tubes. Style TF.

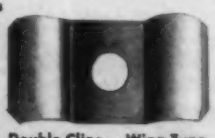
Single Clips

Double Clips

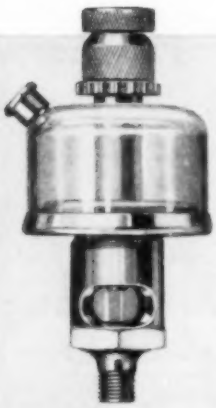


3-Tube Clips

4-Tube Clips



Double Clips — Wing Type



SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem.

Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

SIGHT GRAVITY FEED MULTIPLE OILERS

This one unit replaces 3 to 8 individual oilers. Maximum practicality in a small central lubrication system. Positive cut-off during idle periods. Individual vibration-proof needle valve adjustments. With solenoid control (Illustrated): Style MDS—No. 4685-A. Without solenoid: Style MD

SIGHT GAUGES

For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

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The Standard For Industry For Almost Half A Century

1838-A South Kilbourn Avenue
Chicago 23, Illinois

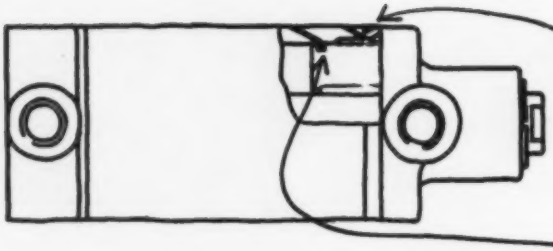
Clip this page for handy "rough reference"

INTER-OFFICE

Engineering Department

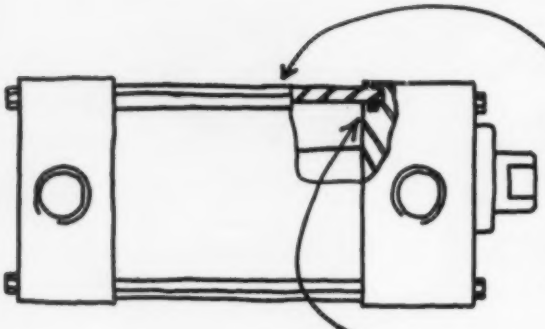
MEMO

Jim - Here's why I think Pathon Hydraulic Cylinders fit our long stroke applications better.



Pathon head is attached by a single screw thread.

Head seal is a true static seal - will give us much longer life.



Higher pressures will stretch the tie-rods on this cylinder - heads will move relative to the tube

This makes head seal dynamic - subject to wear and subsequent trouble

NOTE THIS JIM: Pathon Cylinders fit the bill in shock loads too. We can use the greater strength that Pathon single screw thread attaching method provides.

Tell purchasing to write

PATHON MANUFACTURING CO.
2823 PACIFIC AVE.
CINCINNATI 12, OHIO

ask for catalog #22-A

Ψ could designate P. S. I. - 101

Engineering and Production Men...
Save 3 ways with Reliance Snap Rings

By milling a groove and inserting a Reliance Snap Ring, engineers and production men have found the economical answer to forming shoulders on shafts or in counterbores. The savings in production TIME can be graphically pictured by comparing the work involved in machining inch after inch of solid metal in contrast to just cutting a groove a fraction of an inch wide. MATERIAL is saved instead of being wasted on the plant floor. In fact, less material is required at the start because standard sized shafts can be used. This all adds up to saving MONEY through efficient production.

If you would like the complete story on how Reliance Snap Rings can help your operation, write for Engineering Bulletin 4/K3. No obligation, of course.

RELIANCE DIVISION EATON® MANUFACTURING COMPANY

OFFICE and PLANTS: 515 Charles Ave. MASSILLON, OHIO

Springtites® & Sems · Snap & Retaining Rings · Special Steels · Spring Lock Washers · Hex-Pac-Nuts®

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal

HOW TO

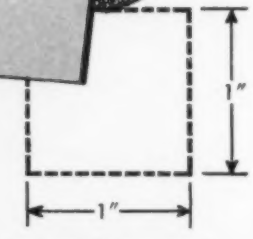
CONTROL MORE THAN

7,000 functions

IN THIS CONFINED AREA

with 3 dimensional

CAMS



Yes, in less than one square inch, about the area of an ordinary postage stamp, the output of the Parker 3 D cam can be expressed as a dependent variable . . . the resultant of two known independent variables which can produce precision functions in split seconds!

$$z = f(xy)$$

where z is the output of the 3 D cam; *x* and *y* are the two known variables.

by Parker

These functions transferred through a follower assembly can activate:

AIRCRAFT—Jet Fuel Injection, Missile Control, Navigational Control, etc.

MACHINE TOOL—Automation Functions Repetitive Production, Feed Back Functions, etc.

COMMERCIAL—Pre-computed Functions Stored Information, Mental-Mechanical Functions, etc.

Send today for FACT FILLED brochure—"3 Dimensional Cams." See how Science SAVES SPACE, produces MECHANICAL SOLUTIONS IN SECONDS!

THE PARKER-HARTFORD CORPORATION

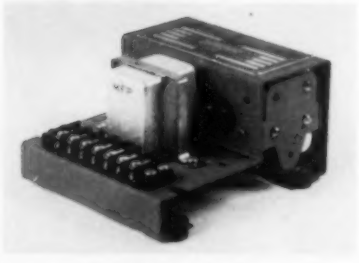
CAM DIVISION

FRANKLIN AVENUE • HARTFORD, CONNECTICUT

by Parker

tiometer and the current rating is 25 ma when the unit is used as a rheostat. Research Instrument Co., P. O. Box 9168, Portland 16, Ore.

For more information—
Circle 77, inside back cover



Fail-safe Monitor for Frequency, Voltage

This over-under voltage-frequency monitor can be used to actuate an aural or visual warning signal when the line is 5 per cent off nominal voltage or frequency and disconnect or turn off equipment at the 10 per cent limit. "Per cent off" points are precisely adjustable, and monitoring functions of any degree of complexity can be performed. Electric Regulator Corp., Norwalk, Conn.

For more information—
Circle 78, inside back cover

Blueprint Files Interlock And Intermember

These blueprint files are designed to meet the General Services Administration requirement that all units shall interlock and intermember with existing units. This means they will interlock and intermember with many standard cabinets of other manufacturers, now in use throughout industry.

They are for both active and inactive filing of blueprints, maps, drawings,

(Continued on page 264)

ACP *Granodine*® IS THE BASE

FOR SPARKLING, DURABLE PAINT FINISHES

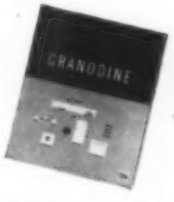
ACP Granodine provides an excellent base for sparkling, durable paint finishes on automotive equipment, home appliances and industrial products by chemically converting steel surfaces to a nonmetallic phosphate coating. It not only greatly increases the adhesion of the finish, but also provides extremely good corrosion resistance even when used in conjunction with a relatively thin and flexible paint film. Granodine coatings are easily and economically applied to steel surfaces by dipping, spraying or brushing.

AN AUTOMOBILE requires a durable paint finish that retains its beauty under all weather conditions—ice and snow, sun and rain. ACP Granodine phosphate coating provides an excellent base for such a finish—greatly increases the adhesion of the paint to the metal.

IN THE HOME, ranges, refrigerators, freezers, washers and dryers are among the many products whose sparkling finish is anchored to the metal by Granodine coating.

IN INDUSTRY, drums, materials handling equipment, machine tools and many other steel products used throughout the plant are protected by a Granodine base.

LEARN ALL ABOUT ACP GRANODINE. Bulletin 1380 describes the various types of ACP Granodine and gives information which will help you select the proper type for your particular application. Write for your copy today.



CHEMICALS ACP PROCESSES

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New Chemical Horizons for Industry and Agriculture

THE VERSATILE SYNCHRON LINE

8 IN. OZ. STANDARD TIMING MOTOR

Widely used in timing machines, time switches, heating and air conditioning controls, action signs, recording thermometers, and other timing devices. Guaranteed to pull 8 oz. direct load continuously at 1 r.p.m.

20 IN. OZ. HI-TORQUE TIMING MOTOR

Ideal power for timing applications requiring continuous motion. Guaranteed for one year. Instant starting, dependable accuracy, and flexible installations. Guaranteed 20 in. oz. at 1 r.p.m.

1 R.P.H. TIMING MOTOR

Guaranteed to pull 20 in. oz. at 1 r.p.h. (1/60 r.p.m.). Synchron's especially developed motor for slow motion timing applications.

SYNCHRON CLOCK MOVEMENTS

Split-second accuracy and long wearing construction, never needs oiling. Front, rear or bottom set, with or without dustproof case. Simple mounting cuts production and assembly costs.

HANSEN MAGNA-TORC DIRECT CURRENT MOTOR

Designed for aircraft instruments and radio controls mechanisms. During World War two it proved rugged dependability in all altitudes and climatic conditions. Easily adapted to other commercial applications.

Actual Size

DEPEND ON SYNCHRON TIMING MOTORS TO MATCH YOUR SPECS

There's a motor for every job in the versatile Synchron line — built by Hansen, quality leader in timing motors

You can depend on Synchron to match your specifications. For long or short duration jobs, fast or slow, the torque you need is in the Synchron line. Fine midget motors with giant power designed, built, tested, and rated to work for industry. Check for yourself. See how Synchron power-rated timing motors can match your specifications — do a job on your design.

DESIGNED, BUILT, AND TESTED FOR LONG-LIFE

Dependable performance in the field is built into every Synchron motor before it leaves the factory. Careful quality control begins on the drawing board and follows every production step. Every motor is subjected to 51 inspections and lab tests before shipment to insure accurate and dependable performance.

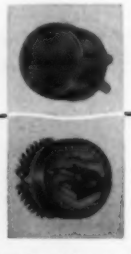
"Workhorse of the industry"

Synchron synchronous motors operate smoothly, evenly in any position; at temperatures from —40° to +140° F.; start instantly under load; pull up to 20 in. oz. at 1 r.p.m. Available in 42 speeds from 0.8 r.p.m. to 600 r.p.m.

WRITE TODAY FOR FULL INFORMATION

Synchron timing motors in all speeds available for prompt delivery

SYNCHRON®

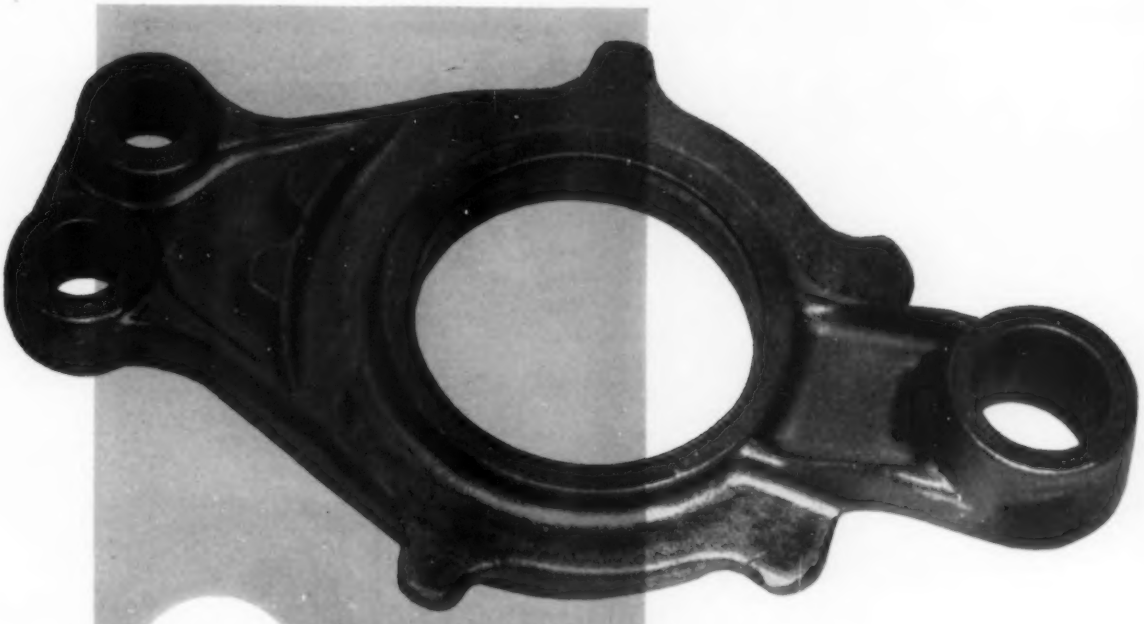


SYNCHRONOUS MOTORS, TIMING MACHINES, CLOCK MOVEMENTS, MAGNATORC D.C. MOTORS

HANSEN MFG. CO., INC.
OUR 50TH YEAR

Princeton 5, Indiana

HANSEN REPRESENTATIVES: The Fromm Co., 5254 W. Madison St., Chicago, Ill. R. H. Winslow Assoc., 123 E. 37th St., New York, N. Y. Electric Motor Engineering, Inc., 8255 Beverly Blvd., Los Angeles 48, Cal. and 3907 Lyon Ave., Oakland, Cal. H. C. Johnson Agencies, Inc., Rochester, Buffalo, Syracuse, Binghamton, New York.



problem: **High machining cost**
Abnormal scrap rejection

Solution:

AmForge Adaption Analysis

Your forging problem is our business. Enthusiastic engineers at AmForge consider each project a new challenge—a challenge to *adapt* AmForge facilities and know-how to your problem. For example, the axle-part forging for truck trailers above was once made as a casting. Although the design more readily adapted itself to casting methods, it was proved that it could be forged. The result was more uniformity, reduced machining hours and less scrap. Being stronger as a forging, the net weight of the part was reduced, resulting in greater payloads with lower maintenance cost for the truckers. Ask us for an AmForge Adaption Analysis. Phone, write or send the coupon.

Brake Shoe **AMFORGE DIVISION**

155 N. Wacker Dr., Chicago 6, Illinois
PLANTS: CHICAGO, ILLINOIS • AZUSA, CALIFORNIA

NEW CATALOG
Mail coupon today

This new 16 page book will give you complete information about AmForge facilities. Send the coupon for your copy today.

AmForge Division, Dept. PE
155 N. Wacker Drive
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Originality and economy are compatible . . . at ARWOOD

INVESTMENT CASTING is one of the few production processes that caters to the creativeness of a design engineer. No more frustration caused by the limitations of conventional processes. And . . . without sacrificing production economy, either!

If application requirements demand that a part be of intricate shape and unusual contour, of metals difficult or impossible to machine, INVESTMENT CASTING provides the efficient and economical solution to your design and production problems.

CASE IN POINT

FREEDOM OF DESIGN. This steel hinge was formerly a complicated assembly composed of a stamped bracket and machined hinge welded together. With investment casting the engineer was able to design the part for utmost efficiency as a single piece with substantial savings in production costs.

A New Service for YOU!

ARWOOD offers a complete finish-machining service, for your convenience. All Arwood plants can now furnish finish-machined castings to your specifications.

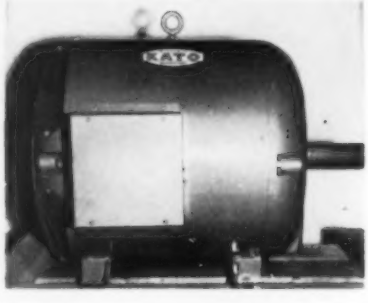
For complete information on Investment Casting and the name of your nearest ARWOOD Engineering Representative, write TODAY to:

ARWOOD

ARWOOD PRECISION CASTING CORP.
325 West 44th Street, New York 36, N. Y.
PLANTS: Brooklyn, N. Y.—Groton, Conn.—Tilton, N. H.—Los Angeles, Calif.
"PIONEERS IN INVESTMENT CASTING"

artwork, tracings, electrotypes, boards, or swatches. Coated-fabric covers flatten sheets to keep them from curling and completely protect them from dust and dirt. Reinforced drawer front construction makes drawers rigid and keeps pulls firmly anchored. Drawers are pre-punched for dividers, and roll on case-hardened ball bearings. Stacor Equipment Co., 768 E. New York Ave., Brooklyn 3, N. Y.

For more information—
Circle 79, inside back cover



Generator for 1200 Cps

This generator will produce approximately 20 kva at 1200 cps. The machine has no separate d-c field exciter. The 40-pole alternator is designed for 125 v d-c excitation from an external source. Generator is 30 x 24 in. wide, and weighs 775 lb. These generators are available in either single or three-phase in all standard voltages, such as 110-220 v or three-phase four-wire 120-208 v. Response time is as low as 0.1 sec. Kato Engineering Co., 1415 First Ave., Mankato, Minn.

For more information—
Circle 80, inside back cover

Speed-Sensitive Relay

Relay allows the use of speed as a controlling quantity. For example, processing or testing cycles can be automatically started after a pre-set speed has been reached. The device can also be used as an under-speed or over-speed limit. Repetitive accuracy of speed detection is said to be better than ±2 per cent. Accuracy of calibration of the standard dial scales is approximately ±5 per cent. The control unit is available in either open or enclosed (NEMA Type 1) forms. The

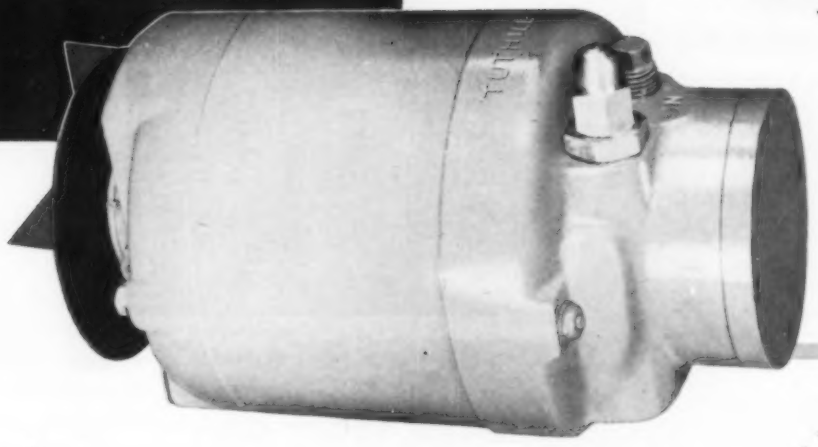
(Continued on page 268)

ANOTHER PUMP PROBLEM... SOLVED BY **TUTHILL**

new POWERMITE

PUMP and MOTOR COMBINATION

• COMPACT • LIGHTWEIGHT
• ECONOMICAL



Here's another example of Tuthill's ability to develop the pump to fit the problem. This compact, new Powermite motor-pump combination, a Tuthill exclusive, was developed to meet the requirements of original equipment manufacturers with unusual space and weight limitations.

Motor and cooling blower have, in effect, been incorporated into the internal gear positive displacement rotary pump. The whole unit takes up no more space than a standard electric motor. A single shaft serves all units of the Powermite—and the elimination of couplings, other parts and labor permit substantial economies for OEM applications.

The pump section contains a built-in strainer, and, if desired, an adjustable relief valve. Powermite can be furnished with cooling blower, as illustrated, or it may be supplied with a shaft extension for driving other accessories.

Powermite can be furnished in a wide variety of pump and motor combinations for use in hydraulic, oil burning, lubricating, and other services involving many different fluids. For example, the model illustrated has a capacity of 18 gallons per hour at 300 psi, and is driven by a 1/12 hp motor at a speed of 1750 rpm.

Manufacturers desiring to investigate the cost, space and weight saving advantages of incorporating Powermites into their products are invited to submit detailed specifications. Or, if preferred, a Tuthill representative will call.

TUTHILL PUMP COMPANY
963 East 95th Street, Chicago 19, Illinois
Gentlemen:
☐ Please have your representative call to discuss Powermite applications in my product
☐ Please send catalog describing complete Tuthill line.

NAME ..... TITLE .....
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STREET .....
CITY ..... STATE .....

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities from 1 to 200 GPM, for Pressures to 600 PSI, Speeds to 3600 RPM.

TUTHILL PUMP COMPANY

963 East 95th Street, Chicago 19, Illinois
Canadian Affiliate:
Ingersoll Machine & Tool Company, Ltd., Ingersoll, Ontario, Canada

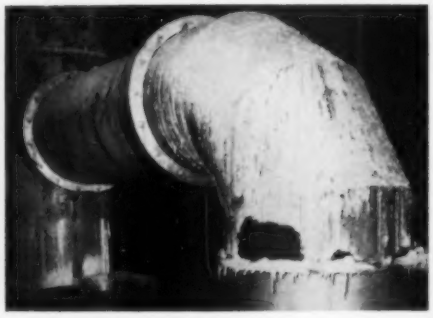
PUMPS FOR YOUR PURPOSE

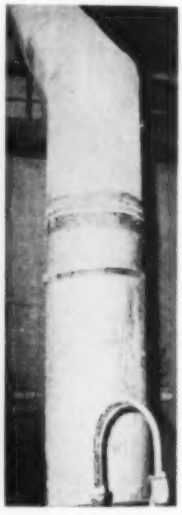
CYANAMID

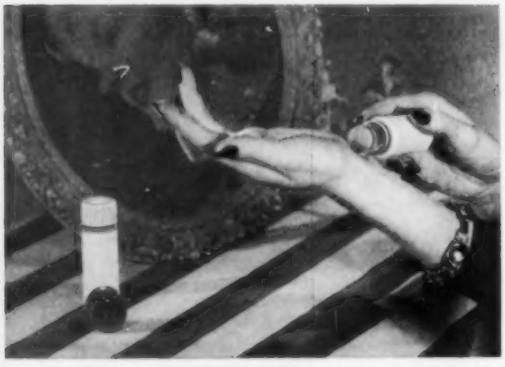
PLASTICS NEWSFRONT

THREE YEARS IN CORROSIVE SERVICE WITHOUT MAINTENANCE

That's the record established by reinforced LAMINAC® polyester resin in venting service on alum digesters at Cyanamid's Warners plant. The carbon steel breech (left) in an alum evaporator required frequent maintenance, failed after less than three year's service. Glass-reinforced LAMINAC stacks (right) in even more severe alum digester service, have needed no maintenance in more than three years. The LAMINAC units cost less in the long run, and were easier to erect and assemble, using either telescope joints wrapped and polyester-welded on the site, or flange-type joints.





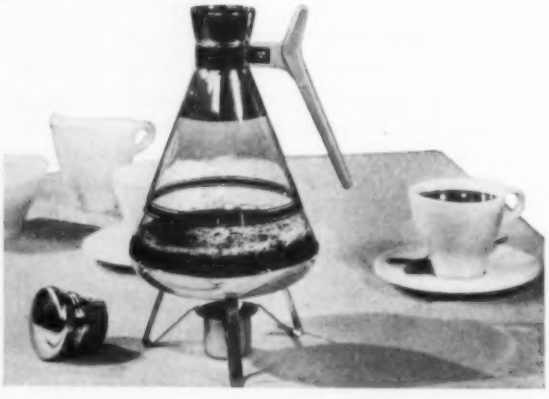


ATTRACTIVE, AIRTIGHT CASE FOR STICK COLOGNE

Six new scents of Avon Stick Cologne are packaged in smartly styled, practical cases molded of BEETLE® urea molding compound. Cases have a white base with contrasting closures in a different color for each scent. Airtight, the BEETLE case stops evaporation of the cologne. Yet the closure opens easily, and with a twist of the wrist the stick pops up for use. The case resists alcohol, essential oils and chemicals as well as staining from perspiration and grime, which wipe off easily.

FUNCTIONAL HANDLES GRACE CARAFES

Any dining or buffet table would be graced by this attractive carafe with its stylish, beige-colored handle molded of CYMEL* melamine molding compound. Elegance and function are combined in the handle, balanced for easy, comfortable pouring. Harmonizing with the carafe's gold decoration, the molded-in color won't chip or wear off. In keeping with its function, CYMEL is exceptionally strong, resistant to heat and flame, and stays cool even when the carafe, made by Club Aluminum Products Company, is full of hot coffee. *Trademark



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PLASTICS AND RESINS DIVISION
40A Rockefeller Plaza, New York 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

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CYANAMID
Plastics and Resins Division
MATERIALS FOR TOMORROW

BCA

BCA offers...
Superior Bearing Performance...plus Manufacturing Flexibility

In even the toughest applications you can count on BCA ball bearings for outstanding performance . . . just as you can count on BCA for the manufacturing flexibility to fill both your routine and emergency needs.

For example, BCA Conrad type single row, deep groove radial bearings sustain combined radial and thrust loads or thrust loads alone—in either direction—even at extreme speeds.

Design features of these bearings include use of largest size balls for optimum ratio of ball diameter to bearing race section at points of heaviest stress . . . deep, uninterrupted ball raceways, precision-ground to conform closely to ball curvature . . . high shoulders on inner and outer raceways to support balls laterally and permit bearing to carry thrust loads equal to 100% or more of the radial load rating.

Call on BCA. We have the experience, the skilled personnel and the facilities to meet your bearings needs . . . under both ordinary and unusual conditions.

ENGINEERS: Send for a copy of BCA's valuable 100-page "Engineering Handbook." Write on your company letterhead. It's free!

BCA

BEARINGS COMPANY OF AMERICA
DIVISION OF FEDERAL-MOGUL-BOWER BEARINGS, INC.
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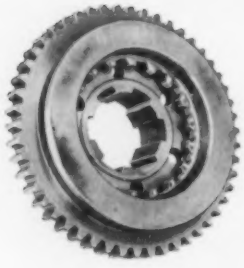
There is only ONE Best Gear Design for each application

. . . and SIER-BATH manufactures it into your gears



Sier-Bath serves you with the best gear design, engineering and manufacturing service. You get free engineering consultation and the finest gears to meet the increased requirements of tomorrow.

Sier-Bath designed and manufactured gears give you the same operating advantages that have brought leadership to many other machinery manufacturers.

No other gear company can now give you PRECISION CROWN-GROUND SPUR GEARS to 12″ diameter, 4 pitch

Send us your gear prints or specs for study and quotation—or have a Sier-Bath gear specialist call to discuss the steps that will make us your ideal gear department.

Sier-Bath PRECISION GEARS

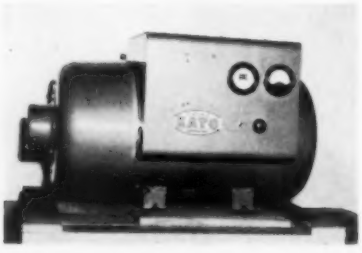
All kinds of gears—all materials.
Made—cut—shaved—ground tooth.
48″ maximum diameter
12 or more of a kind, depending on size

Sier-Bath GEAR & PUMP CO., Inc.
9238 HUDSON BOULEVARD NORTH BERGEN, N. J.
Founded 1905 Members A.G.M.A.

Also manufacturers of Rotary Pumps and Flexible Gear Couplings

tachometer generator is of totally enclosed, non-ventilated construction and can be mounted remotely. Machinery Electrification, Inc., Northboro, Mass.

For more information—
Circle 81, inside back cover



M-G Set Converts A-c to D-c

The machine operates at 1800 rpm. Generator a-c output is 120 v, single-phase, 60 cps, 2500 w. Minimum voltage of the d-c motor is 27½ v and maximum, 29 v. A governor controls the speed of revolution. Machine is 28 x 17 in. high. It weighs 550 lb. Kato Engineering Co., 1415 First Ave., Mankato, Minn.

For more information—
Circle 82, inside back cover

Four Templates For Ellipses

The set consists of four templates, 20, 30, 45 and 60 deg projection. These are also available individually. Each template has a range of 2 to 6 in. major diameter, in increments of ⅛ in. Made of 0.060 in. thick plastic. Rapidesign, Inc., Box 592, Glendale, Calif.

For more information—
Circle 83, inside back cover

Drafting-Reference Unit

A row of these tables serves the men in front as reference facilities and the men behind as drawing tables. The drawing table has easy wide-range height and slope adjustments, and the reference section is equipped with drawer and file space. All units have floor-leveling devices. Stacor Equipment Co., 768 E. New York Ave., Brooklyn 3, N. Y.

For more information—
Circle 84, inside back cover

NEW *Ambi-stat*

temperature controller could be just what your product needs

It's ambient-compensated... compact... economical

Been looking for a temperature controller . . . in the low-cost bracket . . . that won't be bothered by changes in ambient temperature?

Here it is—the new Honeywell *Ambi-stat*. It's the ideal way to control temperatures in such equipment as bulk milk tanks, dry cleaning washers, vending machines, dishwashers, chicken scalders. It makes a highly dependable alarm . . . for high temperatures, or for frost.

New dependability. For the first time in a low-priced control, you get accurate control action regardless of ambient temperatures.

New versatility. Models are available for either heating or cooling applications . . . single or double-throw switching . . . temperatures 0—70 F or 40—180 F . . . nominal differential 2 F or 5 F.

Snap-action switching assures precise, sharp control at the set point. The small bulb . . . ⅜″ in diameter by 3⅛″ long . . . fits readily into your own product design. The complete controller is small, compact, easily mounted on practically any equipment.

REFERENCE DATA:
Write for Specification Sheet No. 866, "Honeywell *Ambi-stat* Remote Bulb Temperature Controllers."

Get complete data, consultation on application, and prices from your local Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—
in Canada, Toronto 17, Ontario.

H HONEYWELL

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

Unusually Tough BOLTS!

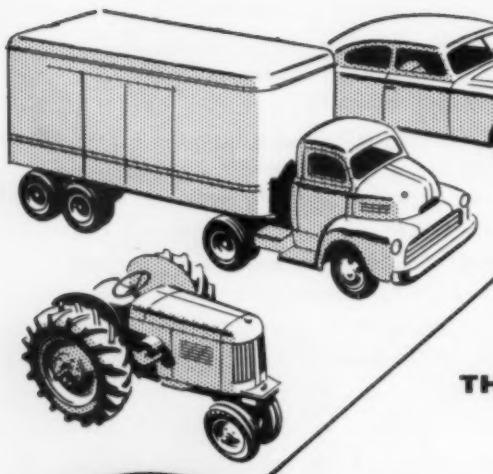
As vital parts of tractors, dirt movers and other heavy-duty equipment, these big bolts can take a terrific beating and still hold fast. They will resist shear, fatigue and impact that no common bolts could withstand without wear or breakage. Special heat-treatment produces this unusual toughness, making these National bolts capable of enduring extremely severe stresses.

By cold heading and special production methods, National can turn out many special headed-and-threaded fasteners which, like these bolts, solve special problems or reduce costs. Depend on National's extensive manufacturing facilities and complete line of fasteners for your needs.

Write for a free copy of National's "Special" fastener booklet.

Representatives in:

Chicago	Indianapolis	Philadelphia
Cincinnati	Kansas City, Mo.	Portland
Dallas	Lansing	Rochester
Denver	Milwaukee	San Francisco
Detroit	Minneapolis	St. Louis
	New York	



MANUFACTURERS OF PHILLIPS RECESSED HEAD SCREWS

THE NATIONAL SCREW & MFG. COMPANY
CLEVELAND 4, OHIO
Pacific Coast: National Screw & Mfg. Co. of Cal.
3423 South Garfield Ave., Los Angeles 22, Cal.

National PRODUCTS

Fasteners Hodell Chains Chester Hoists

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FOR LONGER LIFE

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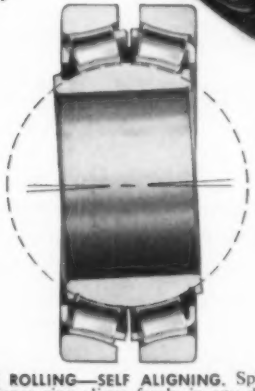
THE equipment manufacturer seeking lower manufacturing costs plus the ultimate in free-rolling efficiency need look no further than this Link-Belt roller bearing.

- **SELF-ALIGNMENT** compensates for inaccuracies in machining and assembly of equipment.
- **EASY MOUNTING.** Bearing is securely and quickly locked by a heavy collar to commercial shafting.
- **COMPACTNESS** offers design flexibility.

You'll find equally important economies throughout industry's most complete line of ball and roller bearing blocks. Ask any one of 40 Link-Belt offices for Book 2550.

Series 400 roller bearings



FREE ROLLING—SELF ALIGNING. Spherical inner ring aligns freely in any direction. Load is distributed over entire roller assuring full capacity. Destructive edge loading cannot occur.

LINK LB BELT

self-aligning ball and roller bearings

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.445-A

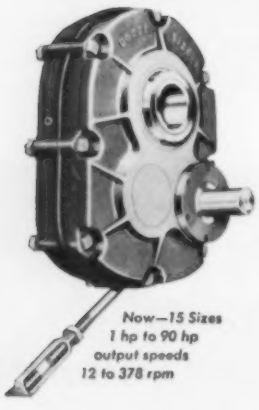
Torque-Arm

SHAFT-MOUNTED SPEED REDUCERS

Size 7 Torque-Arm Speed Reducer on agitator in paper mill

Save Up to 1/3 in Installation

—Deliver 97% Efficiency!



Now—15 Sizes
1 hp to 90 hp
output speeds
12 to 378 rpm

Easy to install! Mounted directly on the driven shaft. Locked at both ends. Dodge Torque-Arm Speed Reducer requires no foundation, no flexible coupling, no sliding base, and there's no lining-up problem. Amazing economy is matched by efficiency in operation—up to 97%.

Unit is driven through V-belt drive. Stock Taper-Lock Sheaves prescribed for each job, permit speed ratios required. Tri-Matic Overload Release and backstop available, if desired. Dodge Torque-Arm is America's most complete line of shaft-mounted Speed Reducers. Ask your Dodge Distributor—or write us.

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1200 Union Street, Mishawaka, Indiana

CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new methods. Look for his name under "Power Transmission Machinery" in the yellow pages of your phone book—or write us.

DODGE
of Mishawaka, Ind.

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 288.

Control Operation Manual–Booklet GEA 6372, 32 pp. Describes manual, magnetic, and reduced-voltage starters; pushbuttons; relays; limit switches; solenoids; pressure and vacuum, float, and plugging and anti-plugging switches. General Electric Co., Schenectady 5, N. Y.

Circle 85, inside back cover

Coated Fabrics–Brochure, 4 pp. Contains data on silicone rubber and Nylon-resin-coated fabrics. Connecticut Hard Rubber Co., 407 E. St., New Haven 9, Conn.

Circle 86, inside back cover

Plastic Rivets and Grommets–Brochures (2). Contains diagrams and data on plastic fastening units. Fastex, 195 Algonquin Rd., Des Plaines, Ill.

Circle 87, inside back cover

Tube Fittings–Bulletin 3061, 24 pp. Contains diagrams and data on steel and stainless steel units. Imperial Brass Mfg. Co., 1200 W Harrison St., Chicago 7, Ill.

Circle 88, inside back cover

Nuts–Brochure, 8 pp. Contains data on units from $\frac{1}{4}$ to 3 in. National Machine Products Co., Utica, Mich.

Circle 89, inside back cover

Tinplating–Handbook, 44 pp. Contains charts, and data about tinplate for buyers and users. Tin Research Institute Inc., 492 W. 6 Ave., Columbus 1, Ohio.

Circle 90, inside back cover

Plastic Plugs–Brochure, 4 pp. Contains data on units for plugging production holes, glides or appliance feet. Fastex, 195 Algonquin Rd., Des Plaines, Ill.

Circle 91, inside back cover

Clutches–Catalog 104-C, 24 pp. Contains charts and data on units for over-running, indexing, and back-stopping applications. Formsprag Co., 23601 Hoover Rd, Van Dyke, Mich.

Circle 92, inside back cover

Temperature and Pressure Sensing Instruments–Brochure, 12 pp. Contains data and specifications on pressure probes, thermocouples, connectors, and termination fittings. Aero Research Instrument Co., 315 N. Aberdeen St., Chicago 7, Ill.

Circle 93, inside back cover

Cold Headed Fasteners–Catalog, 4 pp. Contains data on rivets, nails and threaded parts. John Hassall, Inc., Westbury, N. Y.

Circle 94, inside back cover

Self-Locking Socket Screws–Booklet, 30 pp. Contains data and price list of socket head cap and set screws made from alloy or stainless steel. Standard Pressed Steel Co., Box 545, Jenkintown, Pa.

Circle 95, inside back cover

Photographic Reproduction Materials–Catalog K, 16 pp. Contains processing tips and data on materials for drawings. Grant Photo Products, Inc., 19000 Detroit Ave., Cleveland 7, Ohio.

Circle 96, inside back cover

Pressure Gages–Bulletin 403A, 4 pp. Lists specifications and characteristics of gages. Norden-Ketay Corp., Commerce Rd., Stamford, Conn.

Circle 97, inside back cover

Welded Tubing–Brochure, 12 pp. Contains charts and specifications on tubing including data pertaining to lengths, special shapes, types of finishes and types of steel. Revere Copper and Brass, Inc., 230 Park Ave., New York, N. Y.

Circle 98, inside back cover

Hydraulic Dual Relief Valves–Data sheets (2). Contains schematic drawings and information on units. Fluid Controls, Inc., 1284 North Center St., Mentor, Ohio.

Circle 99, inside back cover

Thermostats–Bulletin 9000, 2 pp. Gives principles of operation, specification data, and ratings. Stevens Mfg. Co., Inc., Lexington, Ohio.

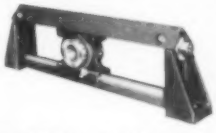
Circle 100, inside back cover

(Continued on page 274)

DODGE PRODUCTS you should know

SC and SCM
BALL BEARING PILLOW BLOCKS

TAPER-LOCK
ALL STEEL CONVEYOR PULLEYS



DODGE TAKE-UPS

DODGE BULLETINS YOU SHOULD HAVE

1. ROLLING BEARINGS. Load ratings, dimensions and other data on Dodge-Timken and SC and SCM Ball Bearings. Bulletin A638.
2. TAPER-LOCK STEEL CONVEYOR PULLEYS. Construction details, sizes, dimensions. Bulletin D56.
3. DODGE TAKE-UPS. Roller Bearing, Ball Bearing, Babbitted. Bulletin D56.

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Check the response-to-the-touch. You can actually feel the difference!

That's why the Paragon Drafting Machine noticeably cuts end-of-the-day fatigue . . . saves costly man hours . . . helps raise working standards.

See how easily protractor control ring can be reached—no matter what position your hand is in. Another time saver. Touch that ring with your *little* finger and scales rotate freely. Release pressure and scales automatically lock to nearest 15° position. And intermediate angles are just as easily set!

Top day-to-day performance is guaranteed by unique "open center" design of arms which protects smooth-working factory-set band tension.

A good look at a Paragon and a touch on that control ring is worth 1,000 words! Try it before you buy *any* drafting machine—you can *feel* the difference.

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Catalogs and Bulletins . . . . . continued

Phenolic Molding Materials and Resins—Brochure CDC 322, 12 pp. Contains data and properties of powders, varnishes and resins. General Electric Co., 1 Plastics Ave., Pittsfield, Mass.

Circle 101, inside back cover

Flexible Couplings—Catalog CP1-56, 8 pp. Contains data, hp ratings, and prices. Acme Chain Corp., Holyoke, Mass.

Circle 102, inside back cover

Cold-Wound Steel Springs—Bulletin, 16 pp. Contains formulas and specifications for helical extension springs and volute and Belleville disc springs. Alco Products, Inc., P.O. Box 1065, Schenectady, N. Y.

Circle 103, inside back cover

Air-Operated Clutches—Bulletin 5011, 2 pp. Contains diagrams and data. Industrial Clutch Corp., Waukesha, Wis.

Circle 104, inside back cover

Fhp Geared Motors—Brochure, 4 pp. Contains diagrams and data. Merkle-Korff Gear Co., Chicago 7, Ill.

Circle 105, inside back cover

Silicone Lubricants—Brochure, 8 pp. Contains data on silicone oils, greases and compounds. Dow Corning Corp., Midland, Mich.

Circle 106, inside back cover

Lubricating Equipment—Catalog 10, 32 pp. Contains diagrams, data and charts on oil cups, dispensers, valves, chain oilers, oiling systems and gages. Oil-Rite Corp., 2318 Waldo Blvd., Manitowoc, Wis.

Circle 107, inside back cover

Thermostats—Bulletin 5000, 2 pp. Contains data on hermetically sealed and semi-enclosed units. Stevens Mfg. Co., Inc., Mansfield, Ohio.

Circle 108, inisde back cover

Electrical Insulating Materials—Booklet B 1050, 60 pp. Describes properties of treated papers, organic varnished fabrics and combination insulations. Westinghouse Electric Corp., Trafford, Pa.

Circle 109, inside back cover

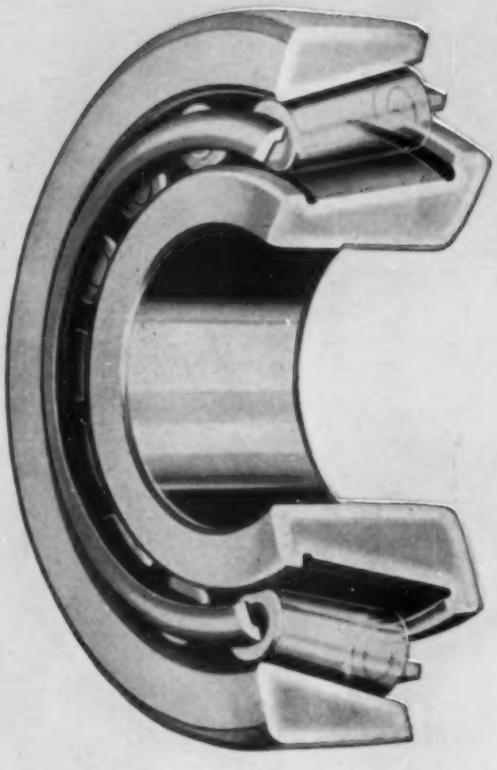
Molded Plastic Gears—Brochure, 4 pp. Contains data on units for reduction ratios from 20:1 to 200:1. Fastex, 195 Algonquin Rd., Des Plaines, Ill.

Circle 110, inside back cover

Fasteners—Booklet, 12 pp. Contains

(Continued on page 312)

There's a BOWER TAPERED ROLLER BEARING engineered to fit your product



Types and sizes to fit a wide range of tapered bearing applications

There's no need to compromise with bearings! Whatever your product, if it uses tapered roller bearings, call in a Bower engineer for expert help on selecting the exact type and size you need.

Depending on your own particular needs, he'll make sure you get the exact size and type—selected from Bower's complete tapered line—engineered to assure maximum performance in your application.

Most important of all, when you specify Bower tapered roller bearings for your product, you get all the advantages of advanced Spher-O-Honed design—less maintenance, longer life, smoother operation. Get the full facts on the *complete* Bower line.

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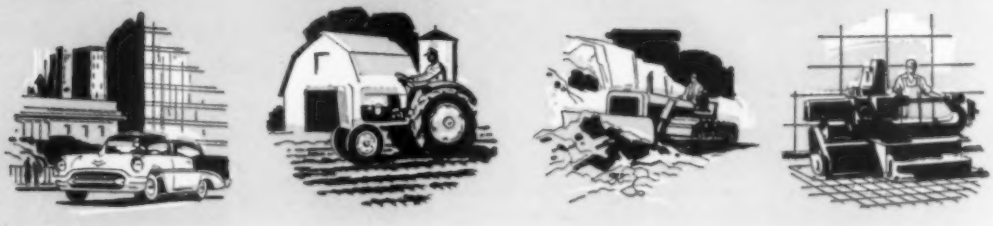

BOWER ROLLER BEARINGS

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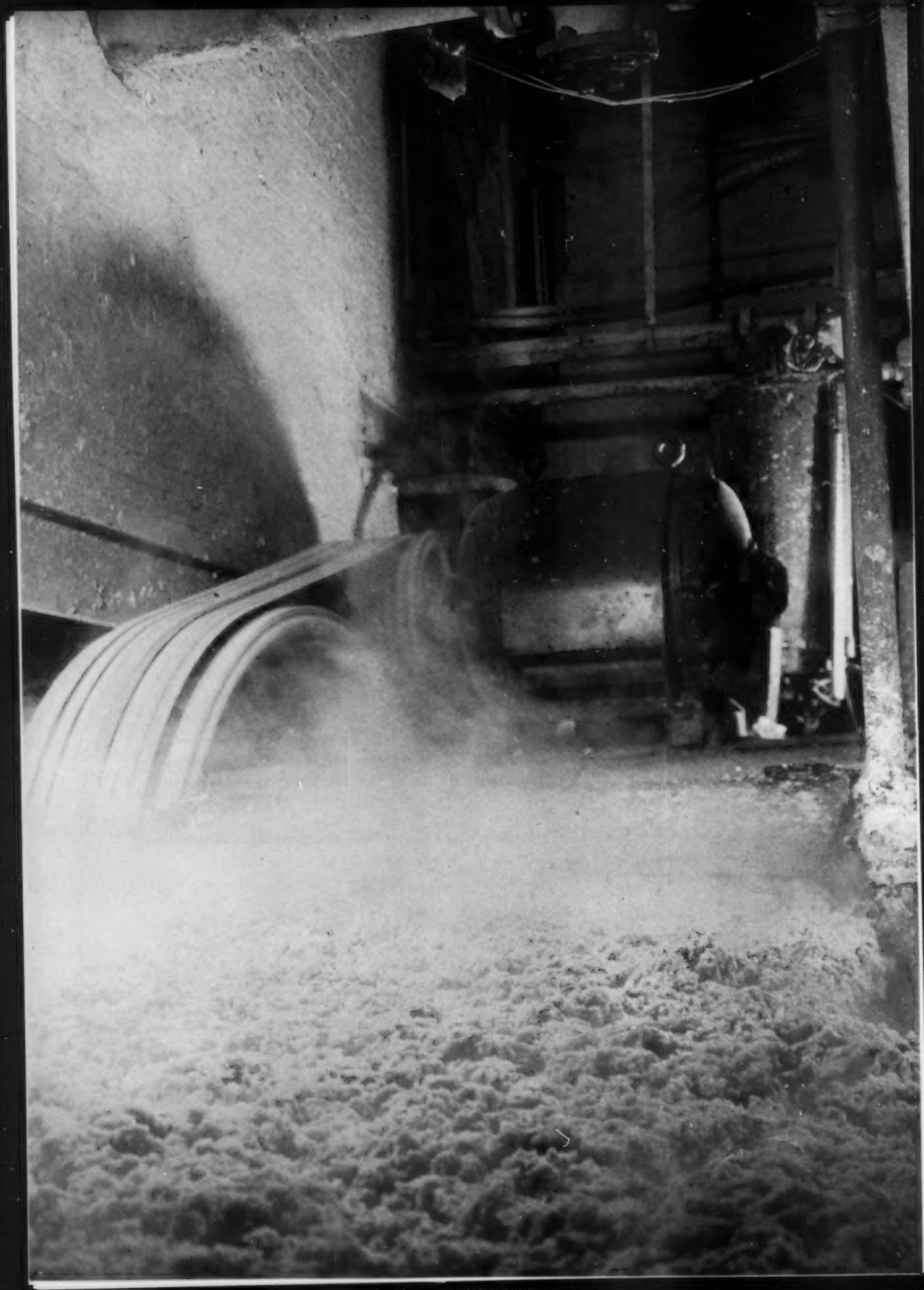

Moisture-laden hot-spot calls for some cool figuring!

Superior design of Louis Allis electric motors pays off under severe heat-humidity conditions

This paddle-agitator drive gets a steady bath of searing hot vapors from the trough below. Yet, the Louis Allis motor has given continuous and reliable service. Here are the special design techniques that make this possible:

Special attention to insulation—Louis Allis sponsors continuous research into new insulating materials. One example: Louis Allis engineers were first to combine Gilsonite with phenolics and alkyds. The result is a varnish with the highest degree of moisture, acid, and alkali resistance — extra-long life for all motor uses whatever your design problem.

Special care in manufacturing—Quality control of all materials . . . careful inspection . . . rigid test . . . all of these add up to the highest quality standards in the industry to assure you of continuous fine performance, dependability under any condition.

These and other Louis Allis extras—such as locked bearings for longer wear, positive lead identification for easier maintenance, and dynamically balanced rotor for quieter operation — could be the answer to your special design problems.

The complete story is in our Bulletin 1700. May we send it to you? Contact your nearby Louis Allis District Office or write The Louis Allis Company, 426 East Stewart Street, Milwaukee 1, Wisconsin.

LOUIS ALLIS

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE-SPEED DRIVES

NEW
high level performance
pressure transducers

by BOURNS

- *High vibration performance*
- *Temperature compensation*
- *Expanded measurement ranges*
- *High reliability*

An entirely new concept in pressure instrument performance combined with Bourns' experience in fine instrument manufacturing.

MODEL 409
Absolute Pressure Transducer

. . . a new design which provides extremely accurate performance characteristics. An advanced mechanism results in low vibration sensitivity for high vibration levels over all pressure ranges.
Temperature compensation and optimum material selection result in negligible temperature effect over a wide temperature environment.
Available ranges: 0-2 psia to 0-100 psia.

Write for Bulletin 409

MODEL 509
Differential Pressure Transducer

. . . a new design with the same *quality plus* features as the Model 409. The diaphragm capsules manufactured by Bourns provide exceptional hysteresis and linearity performance in addition to the low temperature error. These production instruments are assembled and tested to exacting quality standards.
Available ranges: 0-2 psi to 0-100 psi.

Write for Bulletin 509

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TRIMPOT® • LINEAR MOTION POTENTIOMETERS • PRESSURE TRANSDUCERS AND ACCELEROMETERS

data on 128 special units. Buffalo Bolt Co., Oliver St., N. Tonawanda, N. Y.
Circle 111, inside back cover

Laminated Shims—Catalog, 8 pp. Contains data and charts on units of brass, mild steel, stainless steel and aluminum. Laminated Shim Co., Inc., Glenbrook, Conn.
Circle 112, inside back cover

Clutches—Booklet, 76 pp. Contains data on automatic freewheeling clutches, combination clutch-couplings and backstops. Marland One-Way Clutch Co., 561 W. Hillgrove Ave., La Grange, Ill.
Circle 113, inside back cover

Motor Selector—Chart. Contains information on the selection of fractional hp motors from 1/2000 to ¼ hp. Howard Industries, Inc., Racine, Wis.
Circle 114, inside back cover

Plastic Pipe, Fittings and Valves—Catalog P101, 8 pp. Contains data on PVC, styrene-copolymer and Buna N., Vanton Pump & Equipment Corp., 201 Sweetland Ave., Hillside, N. J.
Circle 115, inside back cover

Air Release Valves—Bulletin 856, 2 pp. Contains data on heavy duty valves for pressures up to 500 lb. V. D. Anderson Co., 1935 W. 96 St., Cleveland 2, Ohio.
Circle 116, inside back cover

Gate and Needle Valves—Bulletin DH 80, 12 pp. Contains data on forged steel units designed for the petrochemical, power and process industries. American Chain & Cable Co., Inc., Reading, Pa.
Circle 117, inside back cover

Galvanometers—Bulletin 1528, 12 pp. Contains diagrams, data and charts on units designed to operate at potentials up to 250v. Consolidated Electrodynamics Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.
Circle 118, inside back cover

Magnetic Shielding—Brochure 101, 33 pp. Contains data, performance characteristics and applications of material. Perfection Mica Co., 20 N. Wacker Dr., Chicago 6, Ill.
Circle 119, inside back cover

Force Bridge—Catalog C80-1, 2 pp. Describes a computing device which can be used in pneumatic measurement or control circuits. Minneapolis-
(Continued on page 344)

10-Ton Mayari R Bucket Cleans Floor of San Francisco Bay

Set a clamshell bucket to work on the floor of San Francisco Bay, and you play hob with the bucket's longevity. Corrosion, abrasion and shock take a stiff toll of ordinary steels, and shove bucket-reconditioning costs up high.

The Olympian Dredging Company of San Francisco laid these problems on the table when they planned the construction of a new 7½-yd dredging bucket. The 10-ton clamshell shown above is the end product of their thinking.

The bucket was fabricated from 1½- and 2-in. plates of Mayari R high-strength, corrosion-resisting steel, with all wearing parts hard-faced for additional life. Although the bucket measures 7 ft wide by 9½ ft long, giving it 50 pct greater capacity than the Bay region average, its deadweight is moderate because Mayari R's high strength permits designing in lighter sections.

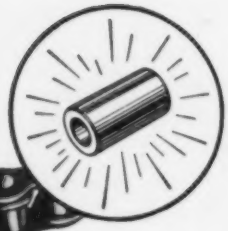
If you have a problem where resistance to corrosion or abrasion, weight-reduction or superior strength are critical matters, perhaps Mayari R would prove to be the practical, economical solution. Our Catalog 353 is full of just such examples in a wide variety of applications. A copy is readily available through the nearest Bethlehem office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

Mayari R...High-Strength, Corrosion-Resisting Steel

BETHLEHEM STEEL



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WHITNEY SELF-LUBRICATING ROLLER CHAIN FOR IMPORTANT SAVINGS —LONGER CHAIN LIFE

A new and exclusive Roller Chain with *built-in* lubrication . . . a product of Whitney Chain research. High strength, oil-impregnated sintered steel bushings oil from the *inside* . . . make chain drives practical and profitable where lubrication cannot be applied, or where normal lubrication may contaminate products in process.

Typical applications include textile, tobacco and food processing machinery, or wherever products must be isolated from lubricants. Here, Whitney Self-Lubricating Chain cuts production costs, gives chain service life far beyond that of non-lubricated chain and is completely interchangeable with American Standard Roller Chain of the same pitch.

Get the facts on this revolutionary development in the Whitney Self-Lubricating Chain Folder covering case histories, wear and impact tests, strengths and sizes available.

WHITNEY ENGINEERING SERVICE

Consult your nearby Whitney Field Office on any of your drive problems. Whitney's complete line of Roller, Silent, Conveyor Chains and Sprockets enables our technicians to help you determine the chain best suited to your requirements.

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ROLLER CHAIN • SILENT CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS

Honeywell Regulator Co., Wayne and Windrim Ave., Philadelphia 44, Pa.

Circle 120, inside back cover

Casters and Wheels–Catalog-C56, 16 pp. Contains data and charts on heavy duty, pneumatic, and semi-steel units. Saginaw Products Corp., Saginaw, Mich.

Circle 121, inside back cover

Temperature Probes–Booklet, 20 pp. Contains data, diagrams and charts on hermetically sealed sensing elements for applications up to 1500 C. Rosemount Engineering Co., Rosemount, Minn.

Circle 122, inside back cover

Thermocouple Components–Specification S005-1, 4 pp. Describes system of connectors for thermocouples and lead wires. Minneapolis-Honeywell Regulator Co., Wayne and Windrim Ave., Philadelphia 44, Pa.

Circle 123, inside back cover

Plate Coils–Bulletin 256, 4 pp. Contains data and charts on heat exchange units. Dean Products, Inc., 616 Franklin Ave., Brooklyn 38, N. Y.

Circle 124, inside back cover

Elapsed Time Indicators–Bulletin A.W.H., 2 pp. Contains data and charts on units designed to record operating time of electrical equipment. A. W. Haydon Co., Waterbury, Conn.

Circle 125, inside back cover

Temperature Regulators – Bulletin TR57, 4 pp. Contains data and diagrams on units for controlling temperatures from 60 to 240 F. Atlas Valve Co., 280 South St., Newark 5, N. J.

Circle 126, inside back cover

One-Piece Window Units–Bulletin 4D, 4 pp. Contains data on circular units that may be used to observe internal operations, indicate flow, or show internal liquid level in machines. Bijur Lubricating Corp., Rochelle Park, N. J.

Circle 127, inside back cover

Precision Switches–Brochure, 8 pp. Contains charts and data on heavy duty units for machine tools. Micro Switch, Freeport, Ill.

Circle 128, inside back cover

Silicone Products–Catalog, 12 pp. Contains charts and data on 150 com-

(Continued on page 285)

Illustrated—Logan Model 400 RFL Unit

Look to Logan

the ultimate in air circuit accessories

Logan RFL Unit, the designers choice for over a decade! Protects your air-powered equipment . . . regulates pressure . . . filters air . . . lubricates air. Adds years of dependable performance.

New Model 400, illustrated above, is a companion model to the well-known Model 600.

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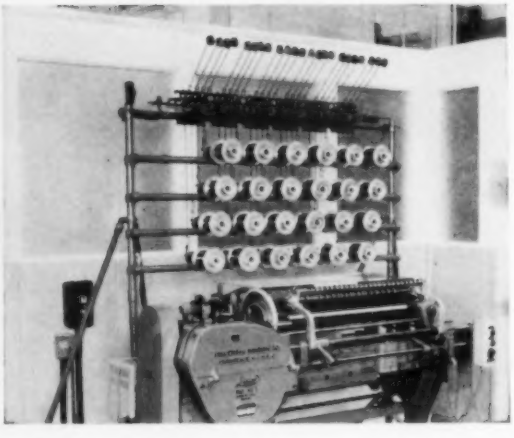

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An ever-increasing number of insulations for an ever-increasing number of electrical and electronic products puts growing emphasis on specialized wires engineered for the job. Your engineered product merits Belden wire engineering service.

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DAPON® resin

superior moisture resistance

Completely protected and locked-in—the excellent electrical properties inherent in cured DAPON resin are protected by the *resistance* of DAPON resin *to moisture in all forms.*

DAPON resin is the *new prepolymer* of diallyl phthalate—a dry white powder with improved properties. It is *easy to handle and store.* Its advent has made possible the use of diallyl phthalate in *all processing methods* for thermosetting resins.

Because the cure of DAPON resin involves addition polymerization, and not condensation, *moisture formation is non-existent* during cure.

Think of an electrical connector with *volume resistivity higher than that of porcelain* with complete protection that guarantees the retention of these properties under the most adverse conditions. This is DAPON resin.

Rid yourself of the moisture problem. Be assured of locked-in initial properties and locked out moisture. *Write now for technical literature containing properties, uses and methods of application for DAPON resin.*

Molding compounds containing DAPON resin are produced by Acme Resin Corporation, Durez Plastics Division, and Mesa Plastics Company.

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ENGINEERING BULLETIN

ON MICRO-BEARINGS

Miniature Instrument Ball Bearings

NEW HAMPSHIRE BALL BEARINGS, INC.

PETERBOROUGH 1, NEW HAMPSHIRE

Subject: **FACTORS TO CONSIDER IN MINIATURE BEARING APPLICATION**

TYPES OF BEARING

The Retainer Bearing fitted with the one-piece crown retainer is well suited for the great majority of instrument applications. Even ball spacing produces good performance at low-moderate speeds, and it can also handle radial or thrust loads. Improved fabricating techniques result in crown retainers being specified for low-torque requirements.

Phenolic Retainers machined from phenolic plastic allow higher speeds and also provide some retention of lubricant. This retainer is used with angular contact bearings where one land is ground away from the inner or outer ring to permit bearing assembly. Such a design permits thrust *only* in the direction of the side having the full land.

CROWN

PHENOLIC

The Full Bearing has a full complement of balls. Filling notches are ground on one side of each ring to allow assembly. This type is steadily being replaced by retainer bearings which cost less to manufacture and assemble. It has an advantage for certain applications requiring maximum radial load capacity, but is unable to handle thrust loads because of possible interference between the balls and filling notches. Contact between the balls creates friction which makes the full bearing unsuitable for low torque or high speed applications.

MATERIALS

Stainless Steel's anti-corrosive properties have made it first choice for bearings used in precision instruments, and it has become one of the standard materials for this purpose. It can be ground and finished to a high degree of precision.

Chrome Steel should only be specified when bearings must operate at critical limits of capacity, a condition not often encountered in instruments. It has a somewhat higher load rating than stainless steel but is subject to rapid corrosion if not protected during handling and use.

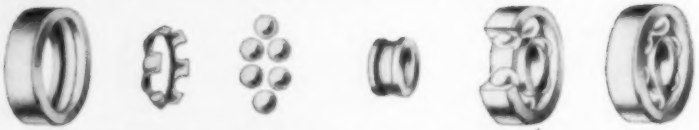
Beryllium Copper should be restricted to applications which definitely require non-magnetic properties in the bearings. All components of the bearing are fabricated from this material. If non-magnetic properties are not required, stainless steel is a better selection.

LOAD RATINGS

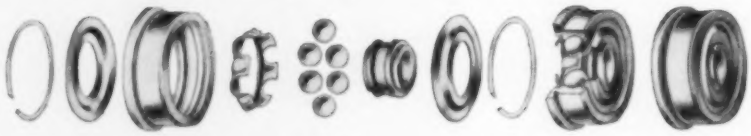
A miniature bearing is seldom operated at or near its rated load capacity. However, the designer must have sufficient information to assure intelligent selection. The load ratings presented in the New Hampshire Ball Bearings, Inc. catalog tables are based on standards established by the AFBMA after extensive studies and tests.

Dynamic load ratings apply to bearings that are rotating. Time-consuming calculations can be avoided by making use of the C factor shown in our catalog.

Static load ratings apply to bearings at rest. Since this exists in relatively few cases, static load rating is not usually given much emphasis. Formulae have been developed, however, and the need for this information is increasing, — primarily for units subjected to shock loading.



Retainer Bearing — Exploded and Assembled Views



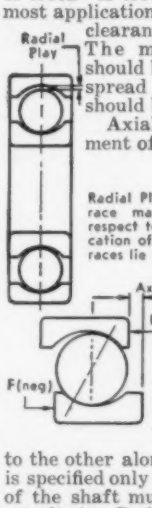
Retainer Bearing — Flanged and Shielded

RADIAL AND AXIAL PLAY

Radial play is the displacement of one ring with respect to the other along the *diameter* of the bearing.

It is important in the successful application of precision bearings and should be specified in orders. A range of .0002" to .0005" is satisfactory for most applications but tighter or looser clearances may be required. The minimum clearance should be .0001" and the total spread from min. to max. should be at least .0002".

Axial play is the displacement of one ring with respect to the other along the bearing axis. It is specified only when axial positioning of the shaft must be held within certain limits. Radial and axial play are mutually dependent factors and the former is the one usually specified.



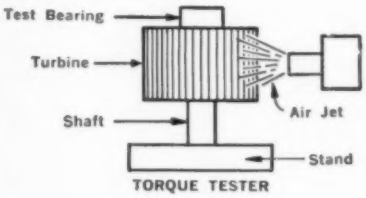
Radial Play — Maximum distance one race may move diametrically with respect to the other without the application of measurable force when both races lie in the same plane.

Axial Play — The maximum relative axial movement of inner race with respect to the outer, when both races are coaxially centered, without the application of measurable force.

TORQUE TESTS

Sensitive instruments require bearings with minimum inherent friction. Starting, or breakaway, torque is most often used to define limits. This is the force necessary to induce rotation from standstill under clearly established conditions of mounting and loading.

Torque tests can reveal much about the true quality and geometry of the bearing. Investigations being conducted constantly are producing valuable contributions to the refinement of instrument bearings.



TORQUE TESTER

MOUNTING PRACTICE

An improper fit to the shaft or housing can cause malfunctioning and failure of a precision bearing. The factors vary so with each application that bearing manufacturers are reluctant to make definite recommendations unless adequate information is furnished. The user cannot be sure that he has selected proper fits unless he has considered the variables involved in the manufacture of both instruments and bearings.

For selective assembly "coded bearings" can be supplied. This involves sorting bores and outside diameters in .0001" increments. It produces four possible groups within the quantity ordered but quantities in any *one* group cannot be assured. Coding should be specified only when definite advantages justify the additional cost.

DESIGNERS HANDBOOK *FREE* TO ENGINEERS

If you work with miniature bearings, you'll find this new, 70 page authoritative publication a great help in solving problems in designing instruments or small electro - mechanical assemblies.

Free to engineers, draftsmen and purchasing agents.

Write New Hampshire Ball Bearings, Inc., Peterborough 1, N.H.

mercially available products. Dow Corning Corp., Midland, Mich.

Circle 129, inside back cover

Electric Motors–Bulletin B2103-1, 12 pp. Contains information on how to select a-c motors. Reliance Electric and Engineering Co., 1088 Ivanhoe Rd., Cleveland 10, Ohio.

Circle 130, inside back cover

Central Lubrication Systems–Bulletin 4C, 24 pp. Contains data on automatic and semi-automatic systems for small machines. Bijur Lubricating Corp., Rochelle Park, N. J.

Circle 131, inside back cover

Ball and Socket Bushings–Brochure, 8 pp. Contains information on heavy duty, self-aligning units. Roller Bearing Co. of America, Sullivan Way, W. Trenton, N. J.

Circle 132, inside back cover

Pressure Gages–Bulletin DH23, 4 pp. Contains data on units for engines, turbines, blowers, hydraulic presses, pumps, and compressors. American Chain & Cable Co. Inc., 929 Connecticut Ave., Bridgeport 2, Conn.

Circle 133, inside back cover

Remote Positioning Controls–Bulletin J-100, 8 pp. Contains data on electrical units for both pushbutton and automatic operation. Jordan Co., Inc., 3235 W. Hampton Ave., Milwaukee 9, Wis.

Circle 134, inside back cover

Custom-Molded Rubber Parts–Pamphlet, 8 pp. Contains data on parts and a description of the relative properties of natural and synthetic rubbers. Tyer Rubber Co., Andover, Mass.

Circle 135, inside back cover

Packless Valves–Brochure, 22 pp. Contains data on units for applications involving hazardous liquids and gases, as well as uses in nuclear energy installations. Robertshaw-Fulton Controls Co., Box 400, Knoxville 1, Tenn.

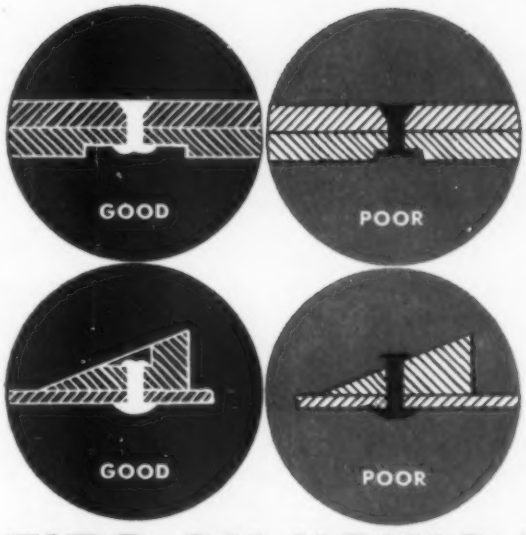
Circle 136, inside back cover

Steel Data–Booklet, 256 pp. Contains information on machining, fabricating, specifications, tolerances, weights, dimensions, elements and safe loads. Joseph T. Ryerson & Son, Inc., Box 8000-A, Chicago 80, Ill.

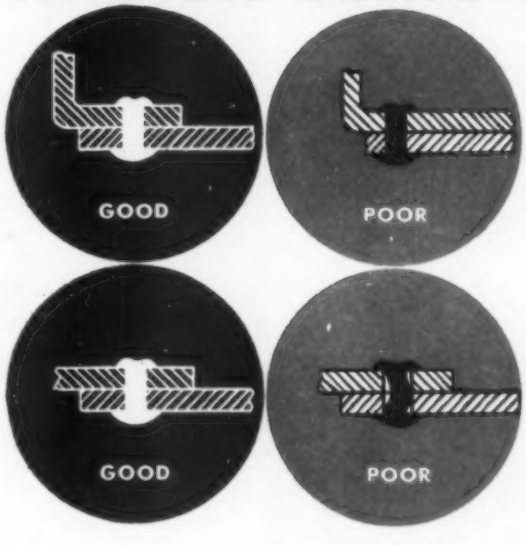
Circle 137, inside back cover

Thermopiles–Brochure, 12 pp. Con-

(Continued on page 288)



TIPS ON USING RIVETS



A short design course guaranteed to save a lot of grief later on!

You could memorize these and thousands more design tips on the best use of rivets—but don't! Much simpler to call on Milford for the right answers to all your riveting design and application problems. Full-tubular, semi-tubular, split, cutlery, decorative—Milford makes them all from any metal that can be cold-formed, then adds a wide variety of platings and finishes.

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... to take full advantage of automatic assembly
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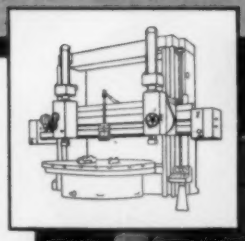
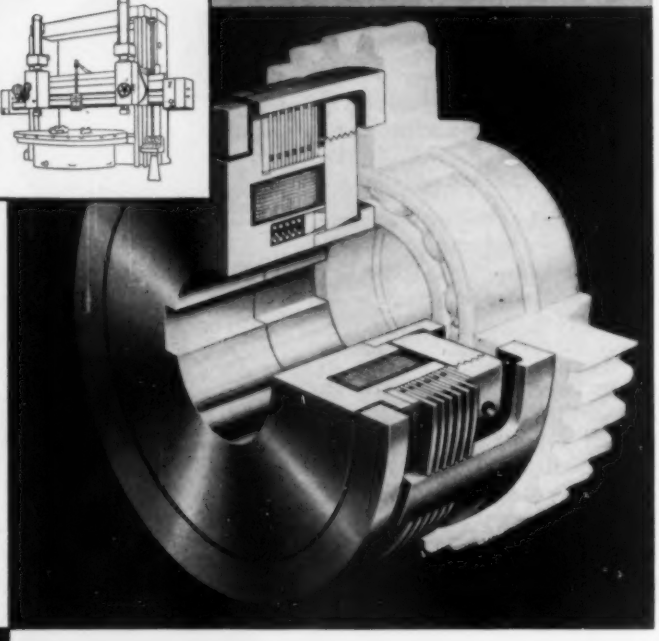
FROM EUROPE...
to American Machine Manufacturers

*** The McCauley Electro-Magnetic Multiple Disc Clutch**





This design introduction was developed for European machine builders and has been accepted by the industry to be a dependable, remotely controlled multiple disc clutch. Now, the McCauley Industrial Corporation has obtained the manufacturing and marketing rights in the United States.

An outstanding feature in the *McCauley clutch design is the elimination of the passage of "Magnetic Flux" through the clutch disc stack. This permits the disc stack to be designed without regard to the magnetic circuit requirements.

Therefore, the most suitable friction materials can be paired to obtain the desired torque characteristics demanded by the type of application on which the clutch is to be used.

In oil applications, such as inside gear boxes, sintered bronze is used as friction material on clutch discs. This material is also effective if loss of oil should occur.

In dry applications, such as electric motor operation, asbestos type friction discs can be used. This dry application design permits use of a clutch where oil is not available.

OTHER FEATURES—

a "Bolt-on", compact design permits ease of assembly; eliminates need for special flanges and spline drives.

b Discs remain free of residual magnetism and, as a result, very little idle torque is developed. Therefore, heat is greatly reduced while running the clutch disengaged at high speed.

c High heat capacity and dissipation.

d Adjustment provided to increase or decrease operating torque.

APPLICATION—

The Electro-Magnetic Clutch offers a solution to many application requirements for precise and remote control with high shifting frequency, and quick response. Torque range is from as low as 10 ft.-lb. to as high as 16,500 ft.-lb. Some applications in which the Electro-Magnetic Multiple Disc Clutch is used are:

Duplicating Milling Machines—Automatic Screw Machines—Punch Presses—Shears—Multiple Bar Machines—Gear Boxes with Multiple Speeds—Stamping Machines—Textile Machinery—Packaging Machines—Lathes—Plastic Fabricating Machinery—Brick Making Machines.

The Power Transmission Division of the McCauley Industrial Corporation has prepared Bulletin 690 which contains a complete description of the Electro-Magnetic Multiple Disc Clutch.

Write for this new bulletin which lists Specifications, Dimensions, Technical Rating Data and Various Illustrated Applications. In addition, McCauley engineers are available to assist in specific application needs.

** Licensed by Stromag Machine Company*

McCAULEY INDUSTRIAL CORPORATION—Power Transmission Division

1840 Howell Avenue, Dayton 7, Ohio • MElrose 3541

"With Weirkote® you can forget plating or dipping after fabrication. It just won't peel or flake!"

Q.—Weirkote—is that a new kind of steel?

A.—*"New" only to those who don't know of its advantages. It's a zinc-coated steel with a skin-tight surface, produced by a continuous galvanizing process instead of the old pot-dip method.*

Q.—Well, we've tried galvanized before for the parts and products we make. But it just couldn't stand up under the punishment of fabrication.

A.—*Must have been the old type galvanized. When you use Weirkote for fabrication, you'll find its surface stands up under the severest stresses. Punch it, lock it, crimp it, deep-draw it—its zinc coating stays intact. It's got a* built-in *resistance to peeling and flaking.*

Q.—Well, say—that'd save all the cost of plating or dipping after fabrication, wouldn't it?

A.—*Exactly! Plus assuring you a* uniform *protective coating at all times—something even a special coating doesn't always provide on the more intricately fabricated parts.*

Send today for free booklet that details the time- and cost-saving advantages of using skin-tight zinc-coated Weirkote. Write Weirton Steel Company, Dept. D-1, Weirton, West Virginia.

WEIRTON STEEL COMPANY
WEIRTON, WEST VIRGINIA
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Sintered Plain and Flange Bearings, Solid and Tubular Bars and Thrust Bearings, Cast Bronze Plain Bearings and Bars are available from stock in a wide range of sizes. Quotations for special bearings or special parts will be sent promptly on receipt of prints.

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tains data on units for conversion of infra-red energy into electrical energy suitable for amplification and measurement. Jarrell-Ash Co., 26 Farwell St., Newtonville 60, Mass.

Circle 138, insid eback cover

Slip Ring Assemblies–Bulletin S-2056, 4 pp. Contains data on brush holder assemblies, brush and leaf assemblies and contacts. Superior Carbon Products, Inc., 9115 George Ave., Cleveland 5, Ohio.

Circle 139, inside back cover

Thermostats–Brochure, 8 pp. Contains data on units that make or break an electrical circuit by responding to changes in temperature or electrical load. Franklin Dales Co., 180 E. Mill St., Akron, Ohio.

Circle 140, inside back cover

Electrical Boxes and Cabinets–Catalog 10, 24 pp. Contains data on junction and pull boxes, conduit boxes, hinged cabinets and fixtures outlet boxes. Spring City Electrical Mfg. Co., Spring City 78, Pa.

Circle 141, inside back cover

Class 3A Threads–Booklet, 16 pp. Describes threads and discusses gaging of these and other classes of external thread fits. Standard Pressed Steel Co., Jenkintown, Pa.

Circle 142, inside back cover

Abrasive Wheels–Bulletin, 74 pp. Contains latest code for abrasive units as approved by the ASA. Grinding Wheel Institute, 2130 Keith Bldg., Cleveland 15, Ohio.

Circle 143, inside back cover

Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

Precious and Base Metals–Booklet, 14 pp. Contains data describing precision-rolled solid and laminated metals. D. E. Makepeace Co., Attleboro, Mass.

Corrosion of Titanium–Book, 175 pp. Contains data on resistance, reactions, applications and studies performed on titanium. Titanium Metallurgical Lab., Battelle Memorial Institute, Columbus 1, Ohio.

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for design engineers and PLANT ENGINEERS

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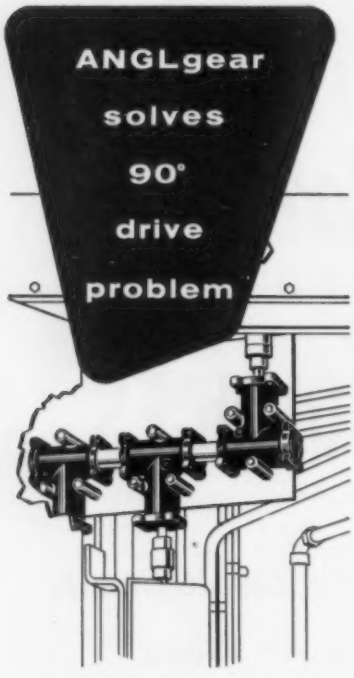

Simplified drawing, based on actual photo, shows ANGLgear installation on Cleveland Punch and Shear Works Co. power press. Compact, universal-mounting ANGLgears provide safe, positive 90° drive for press limit-control switches.

Cleveland Punch and Shear Works Co. engineers selected ANGLgears to actuate limit switches on Cleveland punch presses for these reasons:

First, it was essential to have direct-connected, lagfree control of press stroke, to eliminate any chance of over-runs and consequent injury to operators and expensive dies. Second, the necessary right-angle drives had to be extremely compact, easy to install, and virtually maintenance-free.

ANGLgear met these specifications and Cleveland has continued to purchase the unit.

If you have a 90° power take-off problem, investigate ANGLgear. Completely enclosed, permanently lubricated ANGLgears are available immediately from stock in 1 to 5 hp ratings, with 2 or 3-way shafting, and 1:1 or 2:1 gearing.

See our literature in Sweet's product design file; then contact your local distributor or write direct.

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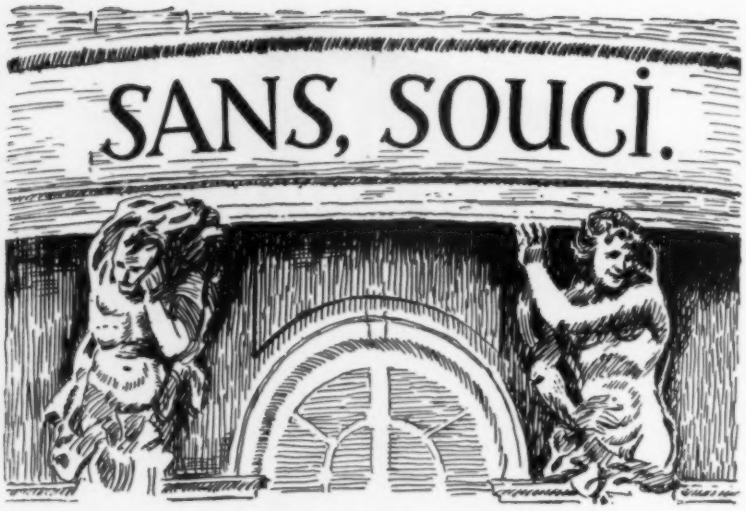
HILLSIDE 5, NEW JERSEY



Ad Libbing by the Editor

On a number of occasions it has been impressed upon me that only too often an individual will have knowledge but very little understanding of the subjects of which he has knowledge. Some times the situations are very pathetic.

I do not think that I will ever forget the college prof who was in this sad predicament. As a boy his father's greatest amibtion was for his son to become a great teacher. To achieve this goal he prodded and belabored his son to achieve high scholastic standing and to graduate with high honors. Indeed, so successful was the father in his proddings that the son graduated at a very early age with high honors, both from high school and from the university. He had learned much but understood very little.

Unfortunately, the father did not realize that his son achieved these goals not because of mental brilliance but rather because of dogged determination. The domineering demands of the father impelled the son to resort to memorization of textbooks in order to make certain that he would get high marks.

Practice makes perfect. By concentrating and keeping everlastingly at it, this young man soon developed a tremendous capacity to memorize page after page of numbers, formulas and text. This gave him such a thorough knowledge of the subjects that he had no difficulty in obtaining high marks on recitations, quizzes and examinations. But the young man had no understanding. Whatever ability to reason he might have had eventually atrophied through disuse.

The years rolled by. Finally the doting father's great ambition was fulfilled. His son became a teacher. At least that was his title. He never was a teacher in fact, and couldn't possibly have been one because he had no understanding of the subjects he tried to teach. When a student would ask for the clarification of statements or definitions that appeared in the text, this prof would recite paragraphs taken directly from the textbook, but could add nothing. The prof was unable to point out the line of reasoning by which the conclusion presented in the textbook had been reached.

Naturally, this teacher failed most miserably when it came to the solution of original problems. Because of his inability to deduce logically or to analyze the simple fundamental problems presented in the books, he often found himself at a decided disadvantage. On one occasion he failed deplorably in attempting to get the answer to one of the problems. Worse still, when the whole solution was explained to him by another prof he still could not comprehend. So he simply wrote the step by step solution in the margin of the page in his textbook and then memorized it perfectly.

Engineering design is a field in which knowledge in itself has little or no value. Only if the designer has a complete and thorough understanding of the principles involved, and can think logically and draw sound conclusions, will he be able to obtain recgnition as a design engineer.

There are no pat answers to design problems. The answer to the problem

(Continued on page 292)

IN FLATWARE, TOO, Sharonsteel Quality STANDS OUT

A thorough knowledge of flatware manufacture — uncompromising adherence to analysis specifications — plus, the industry's finest finishes are reasons why so many of the nation's leading stainlessware makers demand Sharon Quality Stainless Steels.

SHARONSTEEL *For 56 Years a Quality Name in Steel*

SHARON STEEL CORPORATION, SHARON, PENNA.

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cannot be obtained by merely quoting phrases.

All this reminds me of the Chinese story of the father and his extremely stupid son. It seemed to be impossible for the boy to learn anything. The father therefore offered a huge reward in money to any teacher who could teach his son any single thing, no matter how simple. An ambitious teacher came forth and offered to teach this boy the numeral one. The father gave him the assignment. For days and days this teacher drew the numeral one on sheets of paper and repeatedly asked the boy to identify it as a numeral one. Months went by until the teacher felt absolutely certain that the boy had mastered the recognition of the numeral one.

With a feeling of confidence and assurance, the teacher approached the father out in his garden and told him that he had taught his son to recognize the numeral one. The father said, "Such being the case, I will call my son and put him to the test."

When the son came to the father in the garden, the father took his cane and with it made a large numeral one in the sandy dirt of the garden walk.

"What is this mark?" asked the father of the son.

The son looked at the mark in the sand and then at the father and said, "I do not know."

The exasperated teacher shouted, "Don't you recognize the number 1? I drew it for you thousands of times!"

To this the stupid son replied, "None of the marks you made were anything at all like the mark my father made. You made a very small mark on a sheet of paper but father made a great big one in the sand."

And thus it goes in life. Many of our problems we do not recognize for what they are merely because they look so much bigger than the same problems that we had solved so easily many times before.

The story of the Chinese father and his son was told to me many years ago by Chemin Chu Fu, one of the most brilliant Chinese students of the many that studied at American universities under the Boxer Indemnity Scholarship Fund. He and I were much together as students. We sat next to each other at the dining-hall table. He returned to China to take an active part in developing the coal industry. I would love to see him again.—G.F.N.

R&A
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Adhesives

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That's a Teflon liner up there, being bonded to steel pipe. The adhesive is BONDMASTER M620, a single-component, 100% solids epoxy — one of 30 formulations we've developed for bonding metals and plastics (rigid, flexible or foamed) to themselves and to each other.

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"4-way" control valve

Versatile flat-disc type valve is drop-tight . . . provides sensitive throttling action for a variety of rugged control applications.

If you need precise, repeatable control of double-acting cylinder-actuated mechanisms . . . you'll want to try this new advanced-design valve. Ruggedly constructed of a combination of corrosion-resistant materials, it can be used with air, water, gas and oil. Check its features, send for literature.

Send for your copy of new Bulletin 300 . . . for details on design, construction, sizes and applications.

Outstanding features:

- **Trapezoidal ports for modulated throttling.**
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Projection Welding

How to Use It to Improve Product Design and Quality

What is Projection Welding?

Projection welding is a resistance welding process for joining flat or shaped pieces of metal. The two work pieces generally are clamped under electrodes of considerable area that are either flat or made to fit the work. Formed projections or embossments are processed on one of the pieces before welding. Pressure is applied and the current divides equally among the projections and produces welds of approximate equal strength. The heating and pressure process continues until the projections or embossments are flattened sufficiently to bring the work pieces against each other.

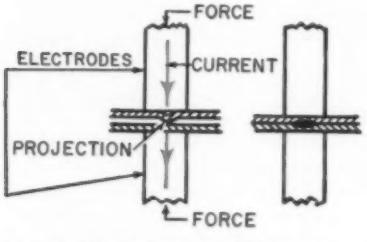

Fig. 1 Projection welding process.

Advantages of Projection Welding

A projection resistance weld requires no additional metal, arcs, gas or flame. *The weld is within the materials themselves*—and is as strong, if not stronger than the parent metals. It offers a 100% strength factor compared to 80% for arc or flame welds.

The simplicity of a resistance welding operation often reduces multi-step fastening operations and enables unskilled operators to produce consistent, high quality welds at peak production.

Many products that were not originally designed for resistance welding can easily be adapted with simple tooling. Costly jigs and fixtures can be eliminated too, because Sciaky resistance welding techniques practically eliminate warpage and distortion of work pieces.

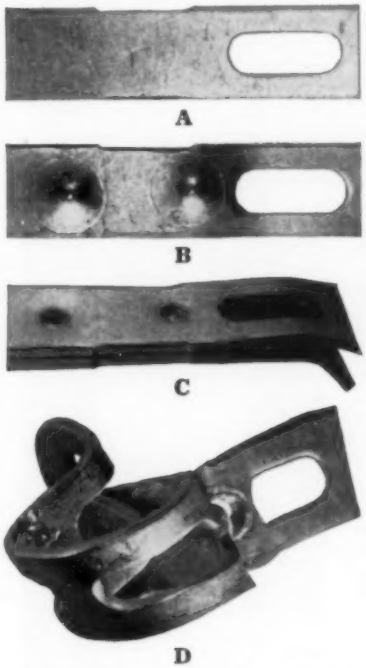

Fig. 2 A. & B. Phosphor bronze clips. Each is .020″ thick and has been first silver, then gold plated. C. The welded part. D. The destruction test. Note the high strength bond and complete nugget separation from parent metal.

When to Design for Projection Welding

As a rule, this application is done in multiple projections simultaneously and also, this technique is very useful where several welds are to be made in a small area. It is often used to attach brackets or fasteners, or to join metal parts having machined projections. Metals of light thickness may be welded to heavy thicknesses. However, various metals do present problems, but with properly applied Sciaky techniques, metals such as aluminum and bronze are readily and effectively projection welded. Note Fig. 2—A, B, C and D.

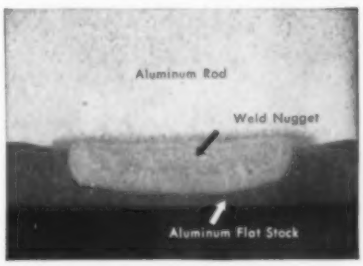

Fig. 3 Macrograph of all aluminum projection weld joining a rod to .062″ flat stock.

Sciaky Research Center

Sciaky's new Research Center invites *you* to submit your fastening design problems. This entire facility, with the latest resistance welding machines, testing instruments, and trained personnel is devoted to solving your joining problems and advancing the application and development of resistance welding.

Write Today for Free Sciaky Literature

Start to build your data file on resistance welding today. Our "Resistance Welding at Work" publication, Vol. 3, No. 2 and Vol. 4, No. 1, contains case histories of Sciaky projection welding techniques. Designers' Guide Bulletin 331 discusses projection welding and other forms of resistance welding.

Describe your particular fastening problem on company letterhead and we will send suitable back and future issues of our "RWAW" publication. All contain impressive examples of Sciaky's basic thinking—resistance welding techniques designed to do *more useful work* at *lower operating costs* with *maximum reliability*.

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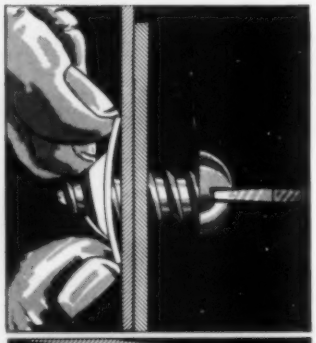
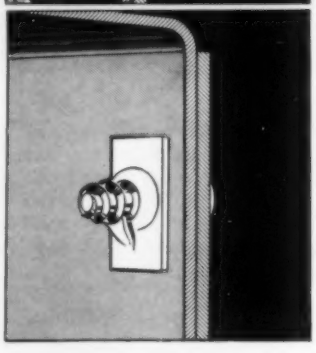
Engineered and designed with the famous 360° grip Prestole impression, Flat Nuts are available in a variety of standard types for immediate delivery to your plant production schedule. In addition, they can be designed and produced in many special sizes and shapes to meet specific requirements and applications.

In either case, they maintain their ability to meet severe torque and tensile requirements and distribute the fastening load over a larger area through Prestole's greater bearing surface. In thousands of applications, Prestole Flat Nuts continue to function long after other fastening methods have failed. Fastening problems of all types are being solved daily by Prestole's engineers and technicians. Consult your nearby representative or write direct to the factory for engineering assistance and service based on years of "know-how" in the fastenings industry.





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ABSTRACTS

Psychological Tests in an Engineering Department

In our department we are convinced that psychological tests have paid us handsome dividends. We believe that, properly instituted and operated by qualified personnel, they will likewise benefit most companies and most large departments.

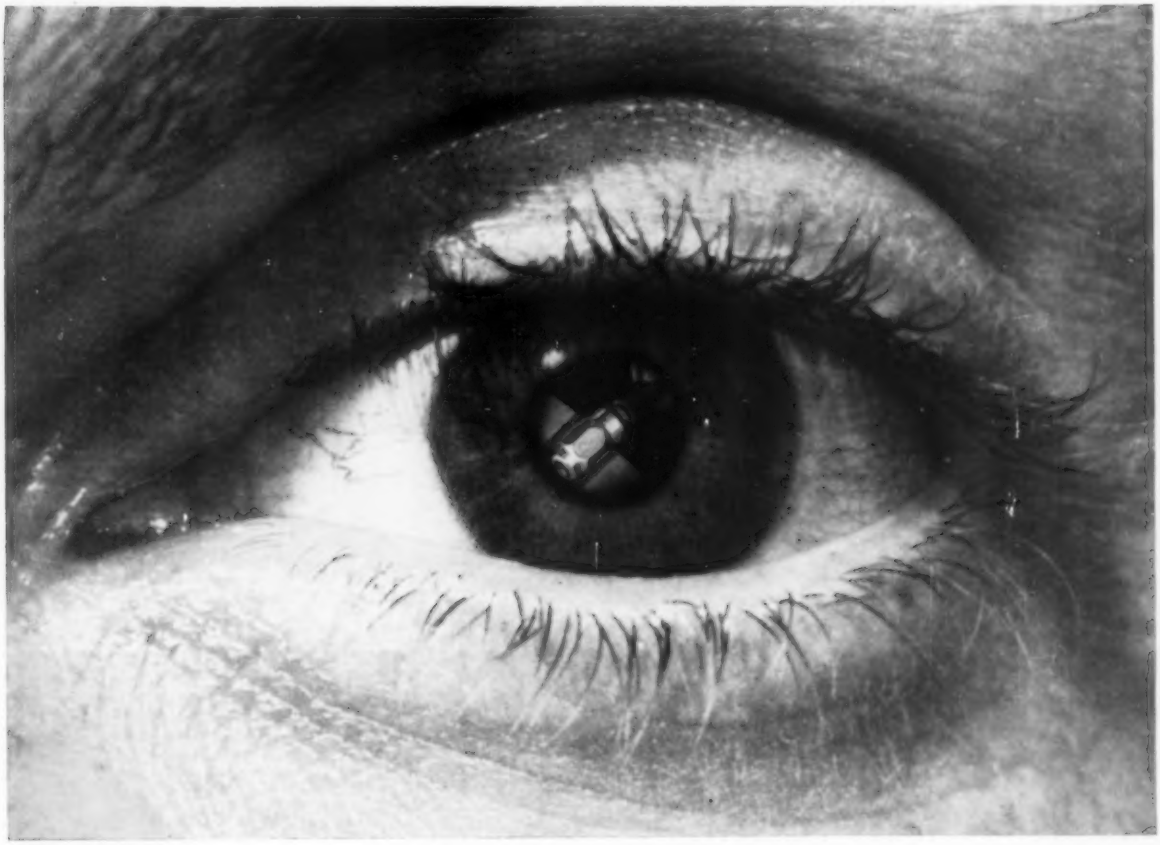
But testing should be thought of as only a part of the selection program. It is a grievous mistake to select solely or even primarily on the basis of test scores. Tests should not supplant other methods of selection, but should be used to implement them and, in fact, to encourage the consideration of other factors. Management must retain its prerogative to employ whom it chooses. It must not make psychological tests either of its instruments or its scapegoat. It must retain the responsibility for hiring and, equally important, it must accept the consequences of its choices.

A company desiring to institute a psychological testing program is confronted with a nearly limitless variety from which it may choose. Hundreds of psychological firms publish thousands of tests. Which one should be selected? Some companies have installed programs simply by buying tests and giving them. Occasionally the programs have been good, but usually they are failures.

In general, if an organization decides that it is desirable to set up a testing program, and determines what are the chief problems it intends to solve, it will want to try out a number of likely tests to see which will prove most useful. Test consultants, after reviewing the particular needs of the organization, can best suggest the test to be considered.

We make use of the Otis quick-scoring mental ability test for engineering applicants. Of the personality tests available we use the Humm-Wadsworth temperament scale. The Humm-Wadsworth scale is of very special value to us in engineering. We are particularly anxious to learn which of our people are most apt to be individual workers, and which are likely

(Continued on page 300)



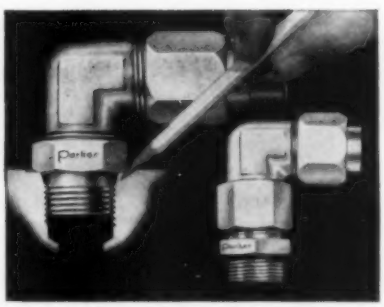
Be sure to see Parker for both tube and hose fittings!

Here, from one convenient source, you can get the most advanced hydraulic fittings available . . . both tube *and* hose. For example, new Parker *no-skive* Hoze-lok fittings require no stripping of rubber-covered hydraulic hose. They're faster, easier to use and *re-usable.*

Also, new Parker *straight-thread* tube fittings solve high-pressure hydraulic leakage problems resulting from tapered pipe threads. *Straight* threads are available on Triple-lok (the industrial standard flare tube fitting) and on Ferulok (flareless fitting for heavy steel tubing).

Parker
Hydraulic and fluid system components

***No-skive* Hoze-lok fittings** need no stripping of hose covers. Only two simple steps complete the make-up. Re-usable.



Straight-thread tube fittings provide leakproof, trouble-free connections. No overtightening. O-ring makes the seal.

TUBE & HOSE FITTINGS DIVISION
Section 422-U
The Parker Appliance Co.
17325 Euclid Ave., Cleveland 12, Ohio

☐ Please send *no-skive* Hoze-lok Bulletin No. 4402
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Where do you belong in

Computer Circuit Design Engineers plan electronic circuitry for advanced airborne analog and digital computers . . . design linear and pulse circuits employing transistors, tubes, magnetic devices. Opportunities also exist in airborne power supply design, or to develop new techniques for marginally checking computer performance. *Do you belong on this team?*

Computer Logical Design Engineers determine the systems outline of a computer and its inter-connection with external equipment. Close liaison is maintained with mathematical support, circuit design, packaging and test engineers. Computer speed, memory size, configuration and arithmetic structure are tailored to requirements of weapons systems. *Do you belong on this team?*

Systems Evaluation Engineers test and evaluate electronic analog and transistorized digital computer systems design for aircraft; evaluate new systems and improvements to insure compliance with specifications and Air Force requirements. Other assignments: tie-in testing of peripheral equipment, liaison with design, development and field engineering. *Do you belong on this team?*

Harry Branning (center): B.S.E.E. 1950, Syracuse. Design Engineer in circuit design, 1951; October, 1954, promoted to Associate Engineer; April, 1956, promoted to Staff Engineer, Systems Planning. In June, 1956, appointed Project Engineer and Manager of the 110 Computer Circuit Design Department; discussing the performance and packaging details of a transistorized read amplifier.

William Dunn (standing): M.E. 1950, M.S.E.E. 1952, Stevens Institute. Technical Engineer, 1955; April, 1956, promoted to Associate Engineer; August, 1956, transferred to Development Engineering in charge of Logical Design for digital computers in advanced weapons systems; here discussing Boolean Algebra method of optimizing the logical design of an airborne digital computer.

Eli Wood (left): B.S.E.E. 1950, Connecticut. IBM Customer Engineer, July, 1950; September, 1952, transferred to ACL Field Engineering. February, 1954, in charge of Field Engineering at Hunter AFB; May, 1955, Associate Engineer; appointed Project Engineer, Manager of Systems Evaluation in August, 1956; here investigating a problem in radar data presentation set evaluation testing.

The brief records of the men cited above indicate only a few of the exciting activities right now in IBM Military Products. This division, organized 18 months ago, has grown enormously. A small-company atmosphere prevails. Men work in small teams . . . individual contributions are instantly recognized. Promotions occur frequently.

As a member of IBM Military Products, you'll enjoy physical surroundings and equipment second to none. Educational programs at IBM expense lead to advanced degrees. Salaries and benefits are excellent. Stability is guaranteed by IBM's history of consistent achievement—underlined by the fact that the rate of turnover at IBM is only one-sixth the national average.

Throughout the length and breadth of the United States IBM has built modern plants and laboratories. This map points out the various locations where you might live as an IBM em-

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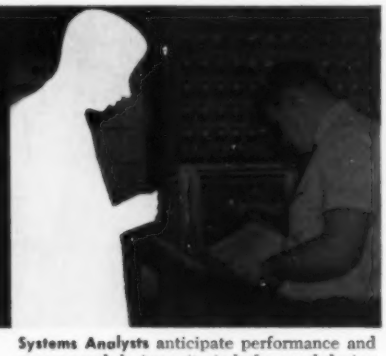
IBM Military Products?

Systems Engineers oversee the engineering support provided by the Systems Coordination and Specification Group to the factory on the AN/ASB-4 Bombing-Navigational System. Air Force requirements are analyzed and the resulting engineering changes evaluated to determine effect on system performance and accuracy. Mathematical error analyses are run. *Do you belong on this team?*



Systems Analysts anticipate performance and recommend design criteria before and during development of equipment. Later, they compare dynamic performance accuracy and reliability characteristics with what has been anticipated. Other assignments include Digital Computer Systems Engineering, Input-Output and Analog-Digital Conversion Engineering. *Do you belong on this team?*

Quentin Marble (left): B.S.M.E. 1951, Syracuse. Joined IBM in 1951; promoted to Design Engineer in 1952; May, 1955, promoted to Associate Engineer, and then to Project Engineer, Manager of the Systems Coordination and Specification Group, Production Engineering Department, in February, 1956; shown here describing a unique cooling design to a new employee in his group.

Monroe Dickinson (left): B.S.E.E. 1952, W.P.I.; M.S.E.E. 1954, M.I.T. Technical Engineer in analog and alternate computer techniques for weapons systems, 1952; Associate Engineer responsible for systems design and analysis, 1954; December, 1955, Staff Engineer, responsible for research planning; here reviewing set-up on laboratory analog computer of a sampled data control problem.

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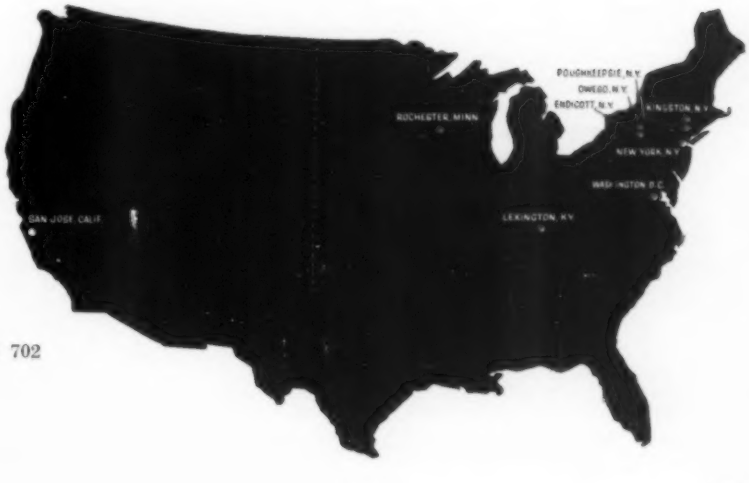

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PREVENTS HYDROGEN EMBRITTLEMENT
REQUIRES NO COSTLY PLATING EQUIPMENT
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The tremendous speeds being achieved by modern aircraft have created a whole new set of design engineering problems. New steel alloys, heat treated to secure higher tensile strengths, had to be developed to withstand the heat generated by extremely high speeds, and to resist the shock of high speed landings.

These completely new high tensile steels require a completely new type of protective coating. Being subject to even greater hydrogen embrittlement than ordinary steels when cadmium plated, these new alloys require Zincilate 410, a protective coating that eliminates all traces of hydrogen embrittlement.

Zincilate 410 (one of several Zincilate formulations) provides other outstanding advantages over outmoded protection methods. Zincilate 410 will increase productive output because the controlled time cycle and size limitations of plating are eliminated. Conventional painting equipment is used to spray, dip or brush Zincilate 410, thus no more costly plating equipment. Zincilate 410 can be applied in the field, without dismantling the damaged part for return to the plating plant. And you can apply Zincilate 410 in your own plant, saving more time and money.

If your product is now being cadmium plated, all these advantages can be yours by simply using Zincilate 410. You may be surprised by the first cost, but you'll be amazed by the savings, which are far greater. Why not outline your coating problem now, on your company letterhead please, so we can tell you frankly what Zincilate 410 can do for you?

Zincilate — CORROSION-RESISTANT, ABRASION-RESISTANT, WELDABLE, AIR-DRIED and BAKED PROTECTIVE COATINGS

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to have supervisory abilities. It is becoming increasingly apparent as experience is gained in pure research as well as in applied company programs, that the area of personality is the most important one in supervisory roles.

Technical skills are relatively easy to measure. Personality factors are far more vital to the success of a supervisor. For him, the ability to handle human relations is the most important of all qualifications. Our tests help us to predict who will best show such ability.

It is also very important to decide who would make the best project engineers and who would make the best design engineers. The Humm-Wadsworth scale is a valuable tool in helping us to predict this. Still another value in this scale is the indications it gives of the amount of detailed supervision likely to be most effective in individual cases, and, to some extent, the type of supervision—forthright or subtle.

The familiar Kuder preference test is given to help determine where an employee's or an applicant's interests lie.

Perhaps the most critical matter of all concerns the personnel operating the program. Tests are no better than the personnel interpreting them. Fully qualified psychologists with Ph.D degrees are rare—it has been estimated that less than 300 psychologists out of 7300 members of the American Psychological Assn. have specialized in industrial psychology. But there is no reason why someone with fewer qualifications cannot do a satisfactory job. As a minimum, he should know tests, be familiar with industrial problems, and should be able to work well with others.

Abstracted from "Psychological Tests in an Engineering Department," by J. M. Parish, Chief Engineer, Louisiana Div., Dow Chemical Co.; presented at Petroleum-Mechanical Engineering Conference, Dallas, Texas, ASME Paper No. 56—PET-3, Sept. 23-26, 1956.

High Pressure Gaskets

The need for gaskets to be used in joints of systems operating at ever higher temperatures has forced a re-evaluation of the established principles of gasketing. Previously, gasketing materials were required to yield as the

(Continued on page 302)

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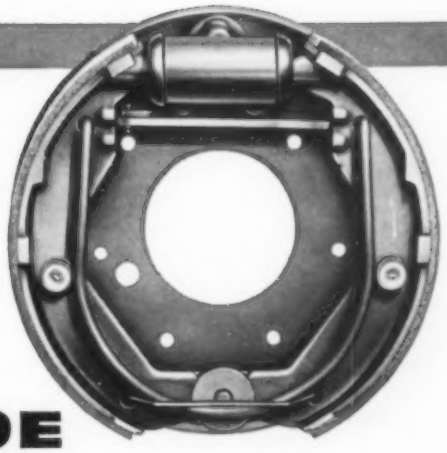

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Unequalled stopping power and outstanding control are characteristic of the FSH. The brake shoes operate with a floating action. This permits the shoes to center themselves in the drum . . . eliminates the danger of liner loads concentrating at one point. The result of this even load distribution is a dependable, controllable brake . . . *in either direction of travel.*

The FSH now is available in a wide range of sizes for dependable control application on industrial, construction and materials handling equipment.

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Mechanical Parking Brake Hook-up. A separate parking brake is no longer necessary with FSH. If specified, the FSH Brake can be furnished with a mechanical parking brake linkage.

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For every industrial, agricultural or automotive application where braking is required!

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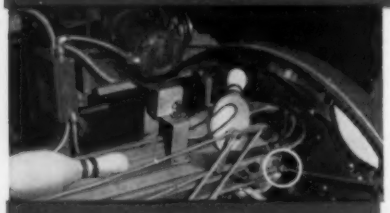

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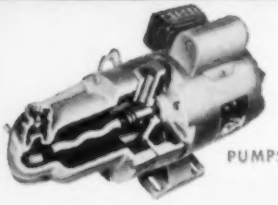

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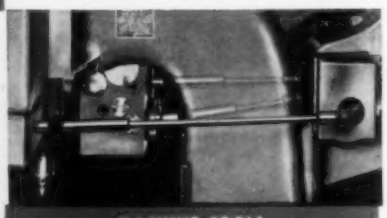

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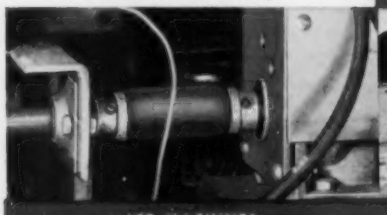

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Whatever you require to solve your design problem involving universal joints and assemblies, you'll find it at Apex, where the more difficult problems get special attention. Catalog 27, including our Universal Joint Data Sheets, should prove helpful. Write, on your company letterhead please, for your copy.

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enclosing flanges were brought close together by the tightening of the bolts. After a certain point had been reached, the gasket was supposed to withstand the application of further pressure.

Gasketing fabricated on this principle proved satisfactory up to pressures of 10,000 psi, but at higher pressures necessary gasket hardness was in excess of the hardness of the flanges. It would no longer have yielded to pressure developed by tightening flange bolts.

The use of soft gaskets which are actually formed by the coming together of the enveloping flanges and form a tight seal without need of extreme flange pressures is recommended on the basis of exhaustive successful tests.

Abstracted from "Extruded Gaskets Solve High-Pressure Problems," by Raymond Mayer, Griscom-Russell Co., Massillon, Ohio, *Chemical Engineering*, Nov. 1956.

Solid Film Lubricants—Factors Influencing Friction and Wear

From the data presented, involving variables in the composition of solid film lubricants, we can conclude that wear life increases with increasing solid film lubricant hardness. The hardness of the lubricant may be varied by: plasticizing the resin binder, addition of waxy additives, modifying the ratio of resin binder to the solid lubricant ratio.

The initial wear rate of the solid film lubricant is high, followed by a low wear rate after the surface has been compressed and burnished. The initial dimension loss sustained is due to film compression and not entirely to weight loss.

From the data derived from studying those variables involved in the application and use of solid film lubricants we can conclude that the wear life of solid film lubricants increases as the hardness of the metal (to which the lubricants are applied) increases; this being due to the fact that wear rate if dependent on contact area. This was borne out for both oscillating and rotating motion.

Wear life of the solid film lubricant decreases with increasing load and increases with increasing surface

(Continued on page 306)

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with FALK *all-steel* MOTOREDUCERS

No long and costly "down time" involved

Motors can be interchanged or replaced *in minutes* with the all-steel, All-Motor type FALK Motoreducer. No long and costly "down time" is involved in making the change!

Best of all, replacement is not limited to original make of motor—new NEMA frames may be substituted for old. This versatile Motoreducer operates with any make, speed or type of standard foot-mounted motor within its AGMA rating. No modification, no special shaft, no "partial" motor required.

In addition to unmatched motor interchangeability, this dependable gear drive—the "work horse of industry"—offers: widest choice of output-shaft position (horizontal, vertical, right-angle)...any output-shaft connection...any mounting, including wall and ceiling...standard speed range from 1.5 rpm to 1430 rpm. All these advantages, plus proved efficiency, low maintenance and extra-long life, make the All-Motor type FALK Motoreducer your best buy for any job requirement.

Furnished in sizes up to 75 hp with any make, style or type of motor; or, *without a motor if desired.* FALK Motoreducers are available from convenient factory, field or distributor stocks, from coast to coast.

Write for Bulletin 3100

THE FALK CORPORATION, MILWAUKEE, WISCONSIN

MANUFACTURERS OF:

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- Speed Reducers
- Flexible Couplings
- Shaft Mounted Drives
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- Special Gear Drives
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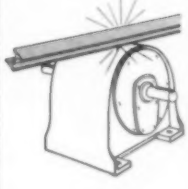
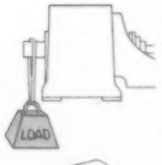
FALK "IN-BUILT" FACTORS assure full dependability—better service—longer life



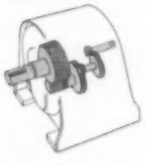
ALL-STEEL HOUSINGS

Rugged, strong, rigid ...all parts heavy steel plate, formed and welded in the Falk Weld Shop.



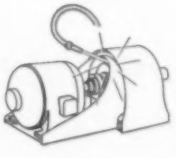
LARGE OVERHUNG LOAD CAPACITY

Large shafts, oversize bearings...rigid mountings with wide bearing spans to handle maximum loads.



PRECISION GEARING

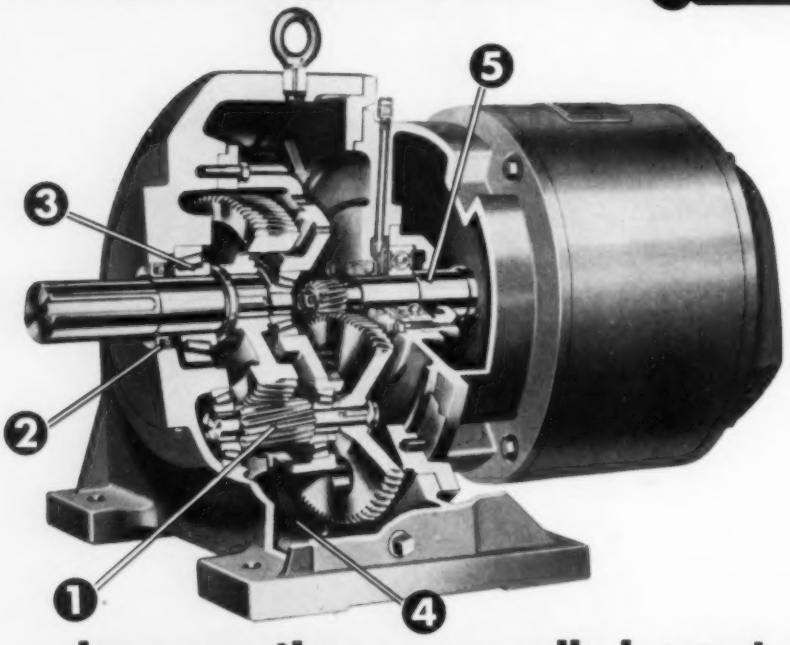
Heat-treated alloy steel gearing, precision cut and shaved after heat treatment to eliminate distortion.



SEALED HOUSINGS

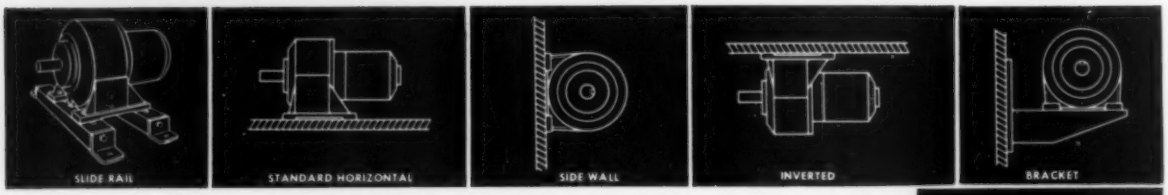
Splashproof, dustproof, oiltight. Dual closures and one-way vents keep oil in, dust and moisture out.

new packaged-power GEARMOTOR



1. HELICAL GEARING assures silent operation, increased strength, longer life and minimum friction loss. Teeth are crown shaved and induction hardened for optimum performance.
2. TWO-WAY SEALS lock oil in, and seal dirt out.
3. OVERSIZE THRUST BEARINGS handle big overhung loads.
4. OIL BATH LUBRICATION keeps gears and bearings continually showered with clean oil.
5. HEAVY SHAFTING, heat treated alloy steel, eliminates possibility of bending or twisting under heavy loads.

. . . gives you these unexcelled construction features

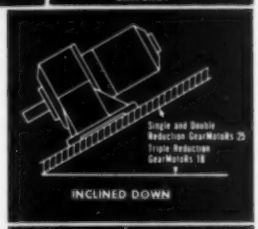


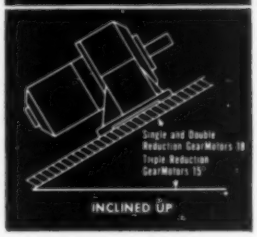
. . . plus real Mounting Flexibility

Exceptional compactness and flexibility eliminate need for costly, special gear units to fit difficult and unusual mounting conditions. For mountings inclined more than shown, a special oil seal arrangement is provided.

For Vertical shaft-down applications, a special Vertical GearMotoR provides a completely leakproof output shaft, through the exclusive Philadelphia "Dry Well" housing construction.

Send for Catalog GM-560 which fully describes and illustrates the new Philadelphia GearMotoRs, Utility type GearMotoRs, In-Line Reducers and Motorized Worm Gear Drives.





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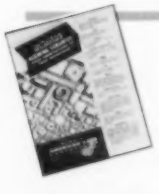
Industry-approved AlSiMag Aluminas are doing an outstanding job in more and more exacting applications calling for **superior electrical characteristics** at high temperatures and frequencies . . . **rugged** resistance to mechanical shock and vibration . . . **chemical inertness . . . resistance to repeated hot-cold shock.** AlSiMag Alumina ceramics are **hard,** measuring 9 on Mohs' scale . . . **strong,** offering extremely high compressive, flexural and tensile strengths. **Precision tolerances** can be maintained. Can be supplied in any quantity.



Write for free copy of Bulletin No. 562 which gives complete details on the most popular of the wide range of special-characteristic AlSiMag Aluminas available.

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time delay relay

for transmitters and other industrial or aircraft applications

Compactness . . . plus **"Mil-Spec"** precision

A complete timer, weighs only 9 ounces. Yet it passes rigid military tests for accuracy, vibration, shock, salt spray, humidity. Developed for radio and radar transmitters, now available for any application that requires this precision, space-saving timer.

As one example, this new timer (HYS series) gets electronic equipment back into service just as quickly as warm tubes reheat to safe operating temperatures. Starts operation *minutes sooner* when tubes have not completely cooled from a previous operation. It's safe. Cuts lost operating time. Standard 28V D. C. Other D. C. ranges on request. Units may be operated from 115V A. C. rectified source. Free bulletin.

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Industrial Timers Division
Moline, Illinois

Please send Bulletin 820 with operation data and specifications on the new HYS series time delay relay.

NAME AND TITLE

COMPANY

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CITY ZONE STATE

speed (between the limits of 0.8 and 24 fpm; this being due to the fact that the coefficient of friction decreases with increasing speed, and wear life is dependent upon the coefficient of friction.

Wear life and wear rate are dependent on film thickness. As the resin binder to solid lubricant pigment ratio increases, the thickness which provides maximum wear life increases.

A solid film lubricant applied to a chrome-plated surface with a 63 microinch finish provides a longer wear life than a chrome surface with a 32 microinch finish, and the 32 finish is better than a 16 microinch finish. A solid film lubricant applied to a finish that has been both sandblasted (63 microinch finish) and phosphated, provides a longer wear life than a surface that has been sandblasted only. This was borne out for both oscillating and rotating motion.

From the data presented, the following conclusions regarding the frictional properties of solid film lubricants can be drawn: the coefficient of friction decreases with increasing load, between approximately 35 and 50 per cent for the loads from 188 to 630 lb, depending on the metals to which the lubricant was applied.

The coefficient of friction is slightly higher for oscillating motion than rotating motion, at the same surface speed, and the coefficient of friction decreases slightly with increasing speed. The coefficient of friction of the solid film lubricants appears to be dependent on metal hardness, decreasing with increasing hardness.

Abstracted from "Solid Film Lubricants-Factors Influencing Their Mechanism of Friction and Wear," by R. E. Crump, Electrofilm Corp., N. Hollywood, Calif.; presented at the Joint Lubrication Conference, Atlantic City, N. J., of the ASME and the ASLE, Preprint No. 56LC-8, Oct. 9, 1956.

Cermet Casting

Casting refractory carbides, oxides, silicides, borides and cermets may be accomplished by preparing a thick slip of the particular refractory with a small amount of binder; the slip is then cast and packed in a mold by vibration, it is centrifuged, and finally

(Continued on page 310)

save money, minutes, metal

with B&W MECHANICAL TUBING

CARBON • ALLOY • STAINLESS

Countless hollow parts and products now being made from solid stock can be fabricated more economically from tubing. The hole is there, eliminating heavy drilling with all its attendant waste. And the wide range of sizes, shapes, analyses, finishes and heat-treated conditions in which B&W Mechanical Tubing is available, make it a semi-finished product in itself — reduce all your machining operations to the minimum.

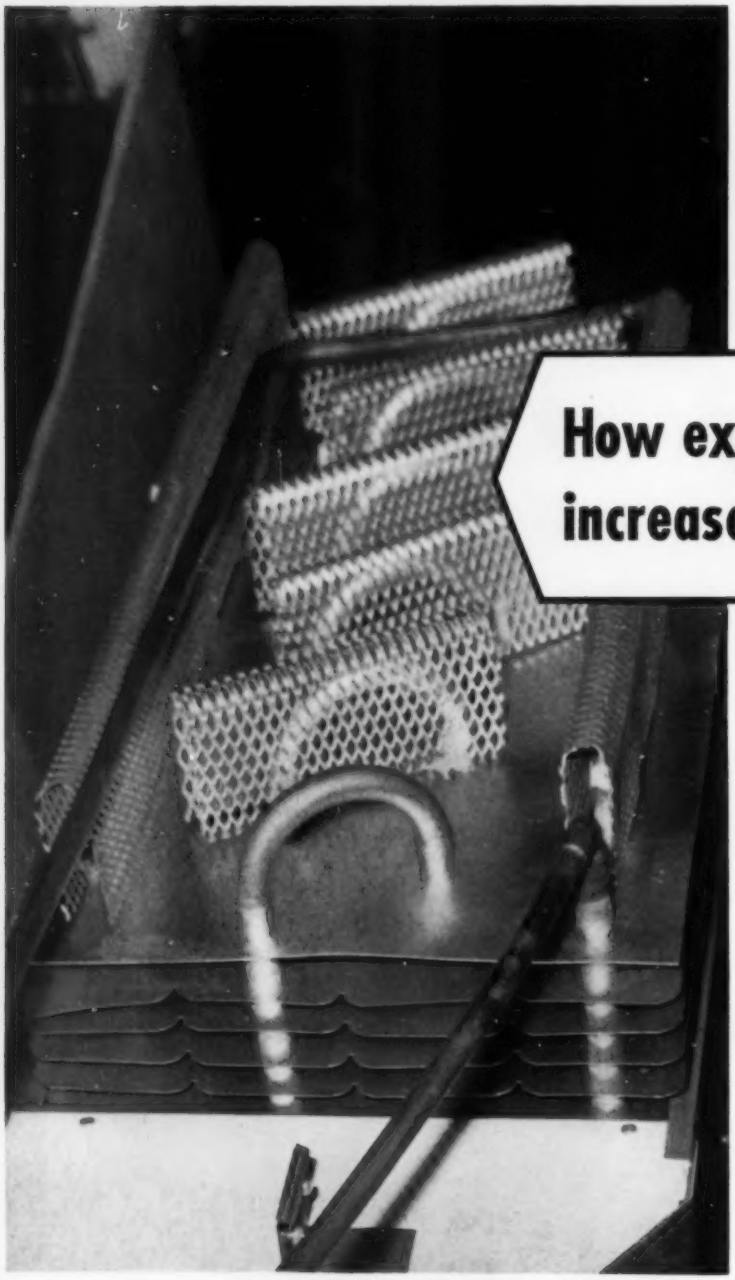
Get the facts on savings from Mr. Tubes, your link to B&W and your local B&W tubing distributor.

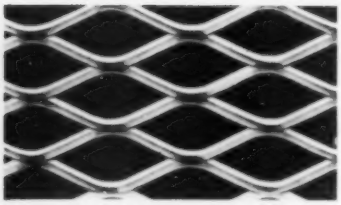
Write for Guide to the Use of Seamless Mechanical Tubing, Technical Bulletin 340.

The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

Seamless and welded tubular products, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels

TA-5031 (G)





How expanded aluminum increased coil efficiency

Anheuser-Busch, Inc., St. Louis, Mo., used Penmetal expanded aluminum in their freezing units to cover the exposed ends of the evaporator coils. This expanded aluminum provided additional prime surface for frost collection on the cooling coils and fins—thus increasing the efficiency of the unit.

But Anheuser-Busch found other advantages in expanded aluminum. Cooling air circulates freely through the open mesh . . . it won't rust . . . can't ever loosen . . . and was easy to shape.

Does the success of this manufacturer open your eyes to a new possibility for solving some problem of your own by using expanded aluminum? Write today, for a reference copy of booklet 507 EM. No cost or obligation.

Penmetal expanded aluminum used to cover exposed ends of evaporator coils in Anheuser-Busch refrigerator-merchandiser.

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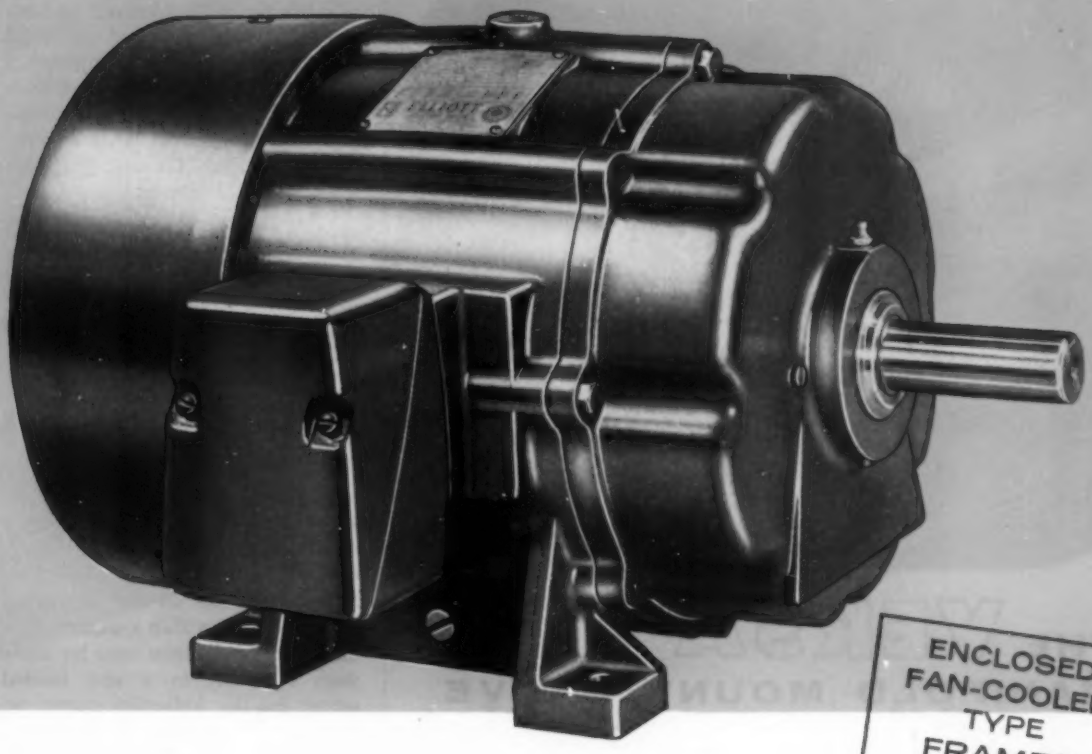


ENCLOSED FAN-COOLED TYPE FRAMES 184-256U

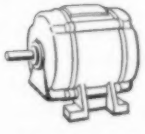
Elliott C-W Type N Motors

NEW PERFORMANCE! You get more horsepower per pound from these compact Elliott C-W motors because of their improved design, and the use of vastly superior insulating materials and electrical steels. Due to greater mechanical and dielectric strength, insulating materials occupy less space. More space is available for copper—the "muscle" of the motor.

NEW PROTECTION! Internal parts of Elliott C-W motors are completely protected by rugged housings — dripproof, or totally-enclosed, as required. Efficient fans assure ample cooling.

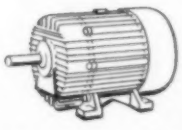
NEW DEPENDABILITY! New Elliott C-W type N motors are designed for the utmost in dependability. They will withstand physical abuse. Use of highly dependable insulating materials assures prolonged life; anti-friction bearings are available in several optional types, to meet severe service conditions.

OTHER C-W TYPE N MOTOR ENCLOSURES



Totally-enclosed non-ventilated

Dripproof Protected



Totally-enclosed, fan-cooled (ribbed frame)

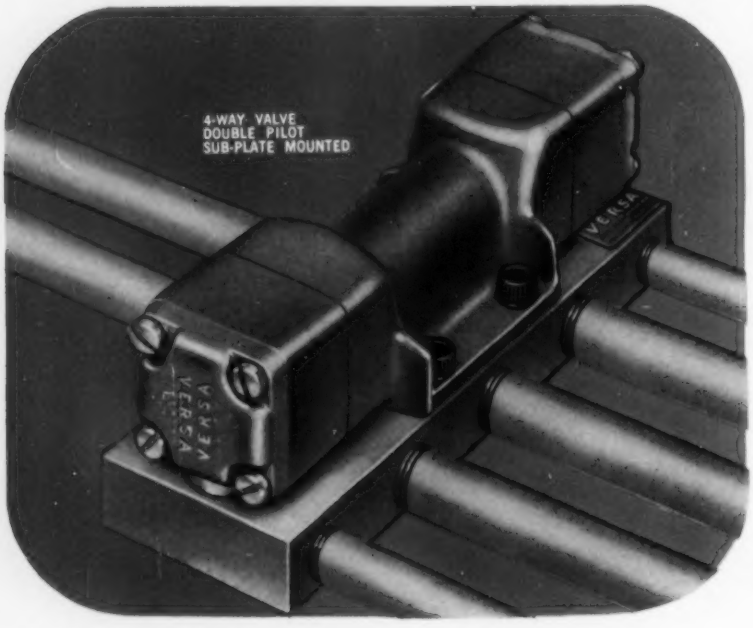
ELLIOTT Company

CROCKER-WHEELER DIVISION

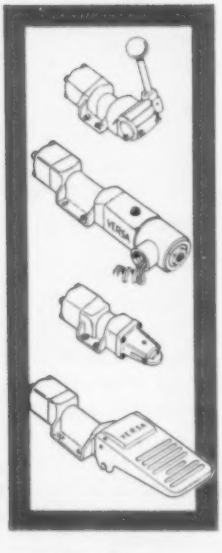
WRITE for new bulletin describing Elliott C-W Type N Motors. Address: Elliott Company, Crocker-Wheeler Division, Jeannette, Pa.

WE 4

FOR MAXIMUM CAPACITY
IN MINIMUM SPACE . . .



THE VERSA
MANIFOLD MOUNT VALVE



The **Versa Manifold Valve** has been especially designed for use where space is at a premium.

All piping can be installed, connected to manifold plate and even purged before installation of the valve itself. The valve is then simply bolted into place on the manifold plate. The valve proper, being independent of the piping, can be easily removed for service or replacement without disconnecting piping or disassembling the valve.

Versa Control Valves are available with any type of actuating device in sizes from ⅛" to 1" NPT, in 2-, 3-, 4-, and 5-way type, and for pressures from partial vacuum to 500 PSIG.

All Versa Valves are triple pressure and functionally tested under water for guaranteed leakproofness.

Over 110,000 Variations . . .
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VERSA

VERSA PRODUCTS COMPANY INC.
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The entire line of VERSA valves is explained in our new comprehensive Folder #14

frozen to retain the shape of the mold. This "casting" is then dried by sublimation, it is sintered and infiltrated with a suitable metal.

While the method has not yet been used on a large scale and additional development work is contemplated, a number of turbine blades have been produced. Present method of producing such blades is to grind sintered blanks to shape. This method is both laborious and expensive.

Abstracted from "Further Investigation of The Feasibility of The Freeze-Casting Method For Forming Full-Size Infiltrated Titanium Carbide Turbine Blades" by E. M. Grala, Lewis Flight Propulsion Laboratory, Cleveland Ohio, NACA Technical Note 3769, Oct. 1956.

Solution of Induction Motor Thermal Circuits

The best method known for evaluating induction motor ventilation systems is a thermal circuit that accurately represents the temperature distribution and all the significant heat flow paths within a motor. Thermal circuits have been used for many years but only to a very limited extent by the induction motor designer.

To solve a thermal circuit that adequately represents the heat flow paths requires a long and laborious hand calculation. With the advent of accurate, high speed computers the use of thermal circuits for evaluating induction motor ventilation systems becomes very attractive. This paper contains a brief description of thermal circuits and a discussion of the computers used to solve thermal circuits.

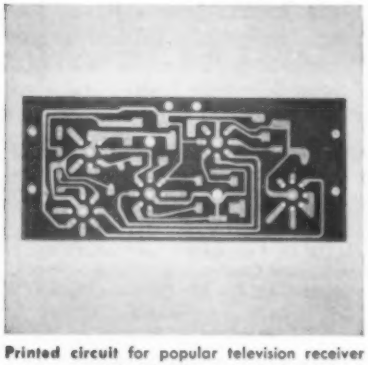
Abstracted from "Application of Computers to Solution of Induction Motor Thermal Circuits," by A. E. Johnson, Associate Member AIEE, General Electric Co., Schenectady, N. Y.; presented at Fall General Meeting, Chicago, Ill., of the AIEE, Paper No. 56-922, Oct. 1-5, 1956.

Mechanical Properties of Iron-Aluminum Alloys

Several variables affecting the ductility of iron-aluminum alloys were examined in detail. Vacuum casting and fabrication techniques were developed to minimize gain size and thereby

(Continued on page 312)

Synthane laminated plastics report for work



Printed circuit for popular television receiver uses a metal-clad Synthane Laminate. Such a circuit eliminates wiring, wiring errors, saves space and weight.

Since the time when the heart of radio was the crystal and cat's whisker, Synthane laminated plastics have been the recommended insulation in the vital and ever expanding communications industry.

Turn on your TV or radio and Synthane goes to work as insulation in coil forms, transformers, tuners, plug-ins, switches, potentiometers, or as the metal-clad base for the entire printed circuit. Synthane also qualifies for important work in radar, sonar and guided missile applications.

Among the varieties of Synthane laminated plastics are several with insulation resistance and dissipation factor capable of controlling TV's high frequencies —even under tropically humid conditions. But Synthane makes over 30 grades—each with its own proportion of useful mechanical, electrical and chemical virtues. You can buy Synthane laminated plastics in sheet, rod and tube form or avail yourself of our complete fabrication service.

We have a number of interesting and informative folders on Synthane properties and applications. A post card will bring them to you promptly. Synthane Corporation, 4 River Road, Oaks, Pa.

COMPRESSIVE STRENGTH

DIELECTRIC STRENGTH

LIGHT WEIGHT

WEAR RESISTANCE

SYNTHANE ...industry's unseen essential

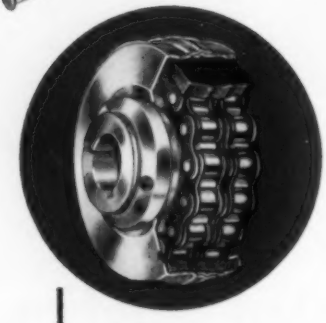
SYNTHANE CORPORATION, 4 RIVER ROAD, OAKS, PA.

Now you can get prompt service on precision, high capacity, Acme Flexible couplings, available in fractional to hundreds of horsepower ratings, direct from your Acme chain distributor.

Acme flexible couplings are used to connect two revolving shafts together, and to compensate for angular and parallel misalignment. Simple to install and disconnect by merely removing one pin.

Maximum capacity is obtained by distributing the load over all the coupling teeth.

An important plus is Acme's use of convex rollers which allow greater angular and radial misalignment. This is accomplished with a minimum amount of backlash. See your Acme distributor.



Each Acme coupling is complete with standard keyways and set screws. Grease retaining felt and snap-on cover can be furnished if required.

FREE FLEXIBLE COUPLING CATALOG

Write Dept. I-K for new Acme Flexible Coupling Catalog. Just off the press.

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reduce the susceptibility for brittle fracture. Quenched iron-aluminum alloys containing carbon exhibited greater ductility than furnace-cooled alloys of the same composition. The difference was accentuated by the addition of ½ per cent titanium.

The yield and tensile strengths of both quenched and slowly cooled alloys increased progressively with aluminum content to a maximum at 14 per cent aluminum and then fell off rapidly. The ductility of all alloys decreased sharply beyond 10 per cent aluminum.

It is suggested that the effects of composition and heat treatment on the mechanical properties of the present alloys can be attributed partly to the occurrence of ordering.

Abstracted from "Mechanical Properties of Iron-Aluminum Alloys," by W. Justusson, V. F. Zackay and E. R. Morgan, Physical Metallurgy Section, Scientific Laboratory, Ford Motor Co., Dearborn, Mich.; presented at the 38 Annual Convention of ASM, Cleveland, Ohio, Preprint No. 36, Oct. 8-12, 1956.

Statistical Analysis of A Wear Process

Experimental results on metal transfer and wear can be interpreted in terms of the statistical behavior of sliding contacts. The size of the sliding contacts is the same in order of magnitude as that for friction tests at very low speed. The results of the analysis support quantitatively the view that Fe_2O_3 films are repeatedly formed and worn off the transferred spots.

Abstracted from "Statistical Analysis of a Wear Process," by B. G. Rightmire, Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge 39, Mass. Paper No. 56-LUB-10, presented at ASME-ASLE Lubrication Conference, Oct. 8-10, 1956, Atlantic City, N. J.

Fatigue Strength of Riveted Joints and Lugs

This reports deals with a number of tests on riveted joints and lugs made for the primary purpose of comparing several types of riveted joints and to study the effect of various factors on the fatigue strength of lugs. The application of single pulsating tension loads presented no difficulty. But it

(Continued on page 316)

CORNING GLASS BULLETIN

FOR PRODUCT DESIGNERS

Practical pampering

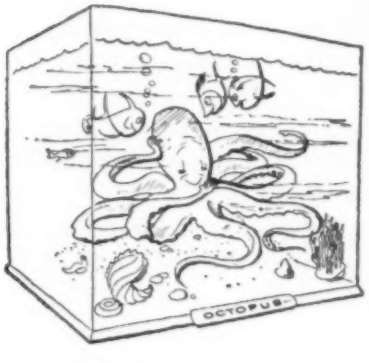
At Marineland of the Pacific, Palos Verdes, California, you'll find a tank of contented, though captive, cephalopods.

But life was not always rosy for these octopuses. (Cephalopod is the order to which octopuses belong.)

Time was when the aquatic zoo keepers at Marineland were octopus-deep in trouble. It began with trying to provide water cooled to the same temperature as the natural environment of an octopus.

Turned out that the heat-exchanger system left copper pickup in the cooled water. And copper is death to octopuses. A concentration of 0.04 parts per million will snuff out the life of an octopus in about two hours. With the going price of about $100 the head, that's a lot of money if you let copper stay in the plumbing.

But the octopuses now happily cavort the day long in water that's cool and pure. The answer—three Corning Glass Works PYREX brand Shell and Tube Heat Exchangers.



O.K., you don't own (or intend to acquire) a pet octopus that needs pampering. Still, there's considerable to be learned from a practical standpoint. To wit—there might be a PYREX brand glass that will answer that knotty problem you're working on right now.

Take contamination, for instance. For most purposes, glass is inert—it just won't mix with, add to, or detract from what you put *in* or *around* it. In the case of PYREX brand glass No. 7740 this aloofness applies to most acids and alkalies, as well as steam under pressure.

Then, too, this glass handles thermal changes with what might be termed indifference since it has a linear coefficient of expansion of 32 x 10^{-7} between 0 and 300° C.

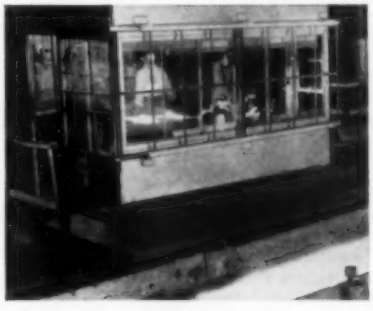
You'll also find that this glass is rugged, readily workable, and available in a wide variety of economical forms.

Suggestion: Put all kinds of useful facts about glass and glass applications at your fingertips. Send for free copies of B-83, "Properties of Selected Commercial Glasses"; and B-84, "Manufacture and Design of Commercial Glassware."

Or, spell out exactly what you need in terms of your problem and let us see if we can't come up with a *glass answer.*

Helping hand in "hot spots"

That's a *glass* shield you see in front of the steel mill shear pulpit operators in the picture.



The glass is a PYREX brand infrared reflecting type. It's heat-resistant, chemically stable and coated on one side with a thin, transparent film of metallic oxide.

Installed with the coated side facing the heat source, it reduces temperature behind the glass 34° F. Yet, operations are still kept under visual observation since this glass transmits about 75% of the visible spectrum.

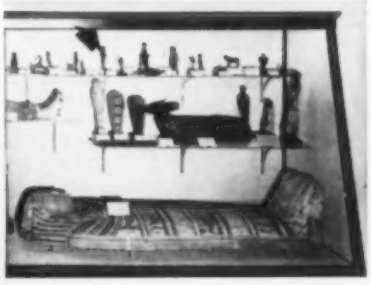
This glass application is just one of the many that may interest men in your shops. They may also have need for such items as fume duct windows, sight glasses, and chemical-resistant surfaces.

Details on all these (along with facts about blue observation glass and the astounding VYCOR brand glass No. 7900) are summed up in the revised version of our Bulletin PE-34. Get a free copy and be set to lend a helping hand in "hot spots."

How to keep a mummy dry

Dampness is no laughing matter to museum keepers—or for that matter for makers (and users) of TV sets, pianos, and such.

That's why Dampp-Chaser, Inc., is in business. They make an ingenious item called, quite logically, Dampp-Chaser.



Behind the top frame (see arrow) is a Dampp-Chaser to keep rare museum pieces dry. Glass tubing by Corning helps in this unusual assignment.

The damp gets chased by a heating element; the heating element is inside glass tubing; the glass tubing is inside an aluminum tube.

We make the glass tubing. Dampp-Chaser, Inc., buys it because it makes a fine insulator, provides protection against leakage, plus an important safety factor in case of accidental over-loading of the circuit. To this we add—glass tubing by Corning is also economical and readily available, no small considerations in the profit picture.

During the past ten years, Dampp-Chasers have rolled up some 6-billion hours of protection against dampness. Glass helped make this a trouble-free record.

Offer: Two booklets to show you the varied ways in which glass is being put to use. "Glass and You" is a sweeping survey that even the people in the front office will appreciate. And for your own files, Bulletin IZ-1, "Glass . . . its increasing importance in product design."

Corning means research in Glass

CORNING GLASS WORKS, 51-2 Crystal Street, Corning, N. Y.

Please send me the following material: Illustrated booklet, "Glass and You" ☐; Bulletin IZ-1, "Glass . . . its increasing importance in product design" ☐; Bulletin B-83, "Properties of Selected Commercial Glasses" ☐; Bulletin B-84, "Manufacture and Design of Commercial Glassware" ☐; Bulletin PE-34, "Corning Flat Glasses" ☐.

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Company_____

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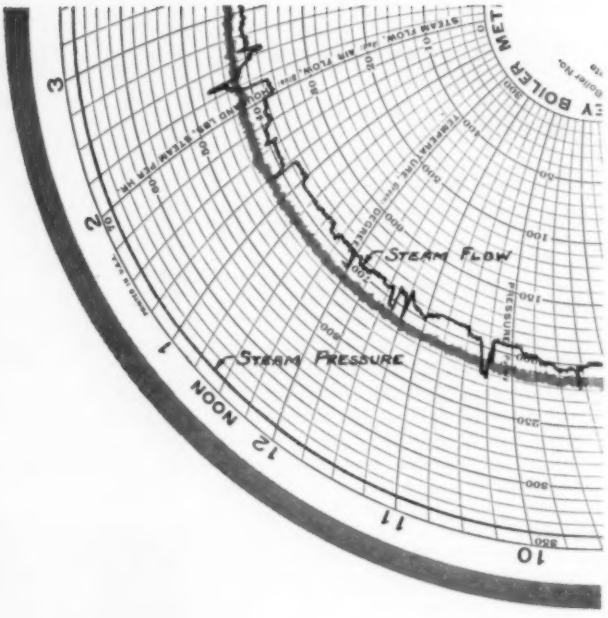
AUTOMATED VARIABLE SPEEDS WITH LEWELLEN V/S TRANSMISSION



This Lewellen equipment is installed on a powdered coal fired boiler, that supplies power and processing steam in a paper mill.

Lewellen V/S Transmission drives coal feeder for pulverizer. Republic damper regulator operates Lewellen controllers — closed loop connected — to regulate fueling rate.

Variable steam demand requires responsive control. Firing rate may speed ten times faster in seconds. Recorder chart shows uniform pressure versus variable steam flow — and establishes precision performance of Lewellen equipment.

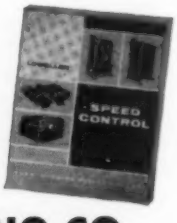
Automatic Control of variable speed operated equipment offers greater precision, increased production, and continuous flow of operations.

Lewellen V/S Transmission offer infinitely, accurately variable speeds, in ratings to 60 h.p., speed ranges to 20:1.

Where metering instruments are used, Lewellen Controllers readily adapt to available regulators and servo devices.

Where rotary, oscillating, or proportional machine motions are available, Lewellen Servos implement the operation.

Automatically controlled speeds compensate transient and cumulative fluctuations—translate motions—to maintain product uniformity and continuity . . . frequently the most direct and effective control of the operation.



Write for Catalog No. 65

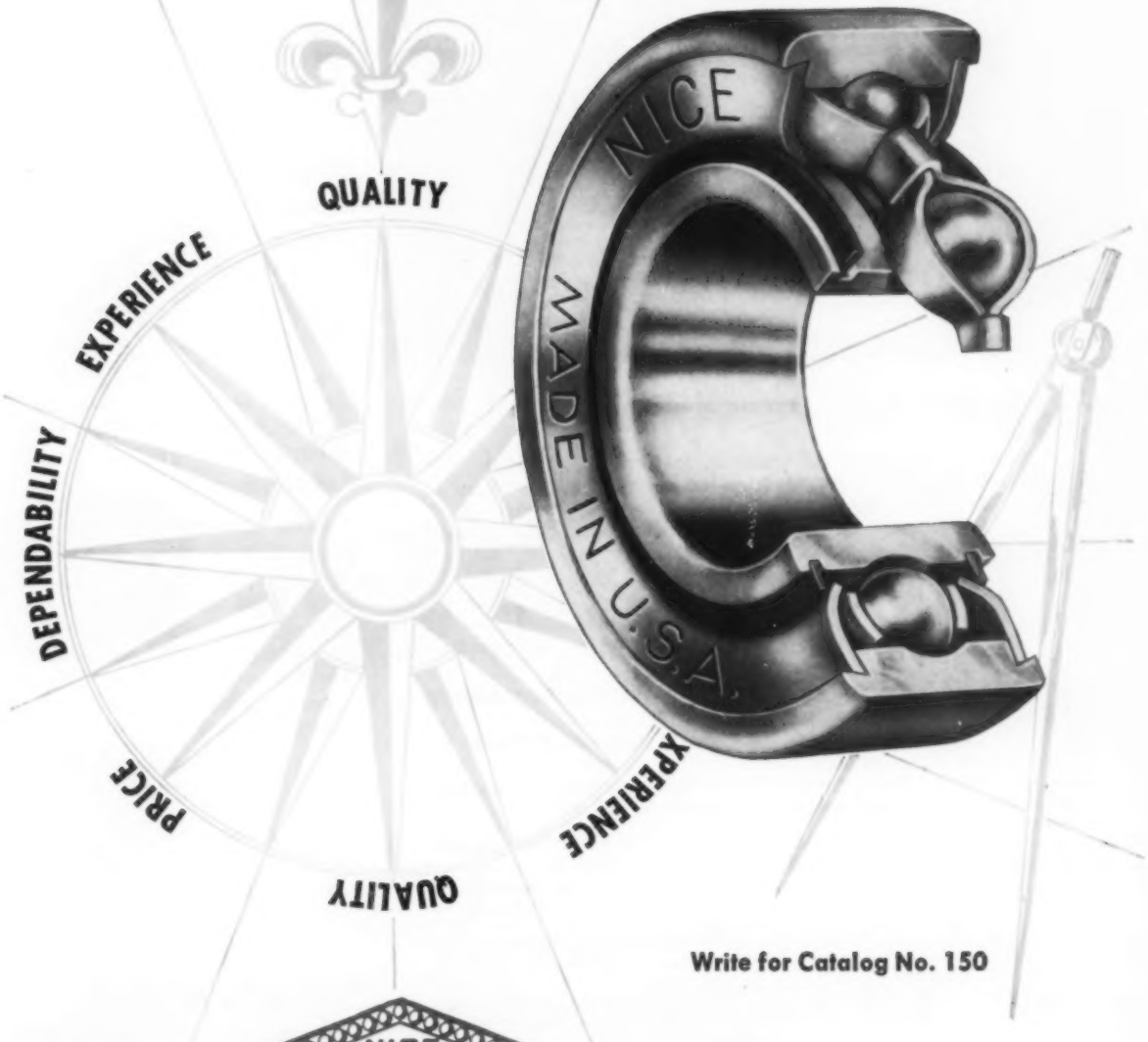
LEWELLEN MANUFACTURING CO.
COLUMBUS, INDIANA

Distributors In All Industrial Areas • In Canada — Peerless Engineering Sales Ltd., Toronto-Montreal

IT'S NICE . . .

TO BE SURE OF YOUR

BEARINGS!



Write for Catalog No. 150

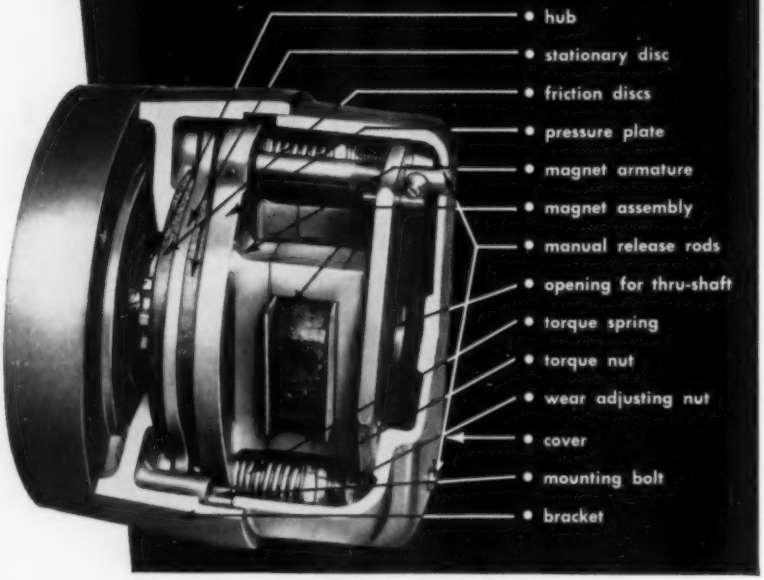
NICE

NICE BALL BEARING CO.

NICETOWN • PHILADELPHIA • PENNSYLVANIA

COMPARISON PROVES

DINGS *direct-acting*
MAGNETIC DISC BRAKES
are your best buy!



COMPARE these outstanding advantages

- Direct-acting for positive, instantaneous stops
- Thru-Shaft design to solve installation problems
- Accommodate standard NEMA shaft extensions
- Designed for mounting on all old and new re-rated NEMA type "C" motor flanges
- Wide torque range—1½ to 175 lbs. ft.—easy torque adjustment
- Fail-safe design in event of power failure
- Simple design and rugged, compact construction

COMPARE for operating and maintenance economy

- No mechanical linkages or levers to maintain
- No solenoids required
- No need for auxiliary fuses, rectifiers, rheostats, auxiliary relays or extra wiring

NEW DINGS EXPLOSION-PROOF MAGNETIC DISC BRAKES
UL approved for hazardous locations

Now Dings combines all the advantages of direct-acting magnetic disc brakes with explosion-proof features tested and approved by Underwriters Laboratories . . . the "707" Series for Class I, Group D hazardous locations, and the "709" Series for Class I, Group C and D and Class II, Groups E, F, G.

Always specify Dings Brakes from your regular motor supplier, or ask about Dings complete engineering service for your brake problems.

DB157½

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is obvious that such tests give the designer insufficient information about the fatigue strength for the combinations of mean load and alternating loads encountered in practice.

Before setting up a program for any further fatigue investigation, a study of available literature was indicated. The aim was to check the extent of the data on fatigue strength. The present report may be regarded as a continuation of report S.357 (ref. 25), sections 5.1 and 5.2 and report S.381 (ref 26), section 4.

An attempt was made at the same time to establish some general conclusions regarding the effect which various factors have on the fatigue strength of the cited joints. Also, a check was made to ascertain whether an estimate of the fatigue life of a given joint at a certain loading could be made from the dimensions of the joint and the fatigue data of the unnotched material.

Abstracted from "The Fatigue Strength of Riveted Joints and Lugs," by J. Schijve, National Advisory Committee for Aeronautics Technical Memorandum 1395, August 1956.

Temperature Effects in Journal Bearing Lubrication

Treating viscosity as a function of temperature and pressure, the problem of a journal bearing without side leakage is solved for the temperature and pressure distributions for the case of adiabatic flow of the lubricant subject to the Reynolds boundary conditions. A numerical example is solved to illustrate the method.

Abstracted from "Temperature Effects in Journal Bearing Lubrication," by W. F. Hughes, Assistant Professor and J. F. Osterle, Associate Professor, Dept. of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. Preprint No. 56LC-11, presented before Joint Lubrication Conference of ASME-ASLE, Oct. 10, 1956, Atlantic City, N. J.

Surface Roughness

The minimum hydrodynamic oil-film thickness of a short journal bearing is defined as that value of the minimum oil-film thickness at which marginal lubrication procedures initially are substituted for hydrodynamic-film lu-

(Continued on page 320)

How you can save time and money with

Harvey Aluminum Impact Extrusions

Many engineers and designers are overlooking the exclusive advantages of aluminum impact extrusions. This advanced metalworking operation offers design flexibility; versatility of alloys; draft free, close tolerance parts requiring minimum machining; smooth surfaces; and significant savings in man hours, machining, and material.

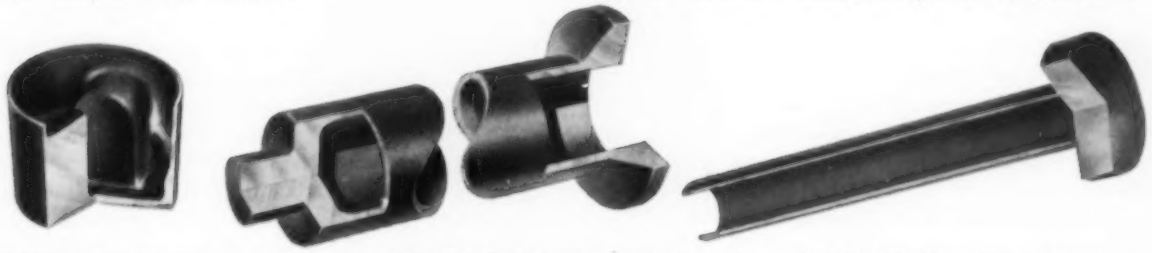
Custom configuration with precision tolerances

Typical applications of Harvey Impact Extrusions are illustrated below. Harvey Impacts have a smooth surface and require no machine finishing for most commercial, ordnance, airframe, and missile applications. Harvey's integrated services provide an economical, quality product that meets all specifications of high strength, light weight, resistance to corrosion and heat, critical tolerances in wall thickness, maximum heat conductivity, and low unit cost.

Harvey Aluminum leads in impact extrusions

Harvey pioneered in the impact extruding of intricate configurations. This experienced leadership, plus technical know-how and the most advanced facilities, are available for your own specialized design requirements. The integrated Harvey engineering team of research, design, metallurgy, and quality control will expedite your product from drawing board to finished product quickly, efficiently, economically.

If you have a design that calls for hollow, closed end sections... high strength... zero-degree walls and surfaces... unusual length to diameter ratios, integral ribs, fins, and bosses... close tolerances... with volume production, low unit cost... *your Harvey Field Engineer will be happy to show you how Harvey Impact Extrusions can help solve your design problems.*



PISTON made with flat top or dome. Applications for aluminum pistons range from light horsepower engines to automotive and aircraft motors. Highest physical properties, surpassing any forging or casting. Metallurgical characteristics of Harvey alloys insure highest fatigue strength, excellent grain structure, best heat dissipation.

LANDING GEAR COMPONENT provides highest physical properties, greatly reducing material and machining costs. The impact, obtainable in various lengths, is made from aluminum alloys which assure optimum internal grain structure. This impacted piston replaces costly method of hogging out bar stock or machining a forging. Diameters of barrel are held to close tolerance dimensions with superior surface finish.

TUBE SUPPORT provides solid head on one end of tube. This unique aluminum impact extrusion offers the most economical fabrication method for a support tube application without sacrificing high physical properties. Aluminum impact eliminates considerable machining, offers maximum design versatility. Available in a range of sizes and alloys.

Making the most of aluminum... for everyone

HARVEY ALUMINUM SALES INC., TORRANCE, CALIFORNIA

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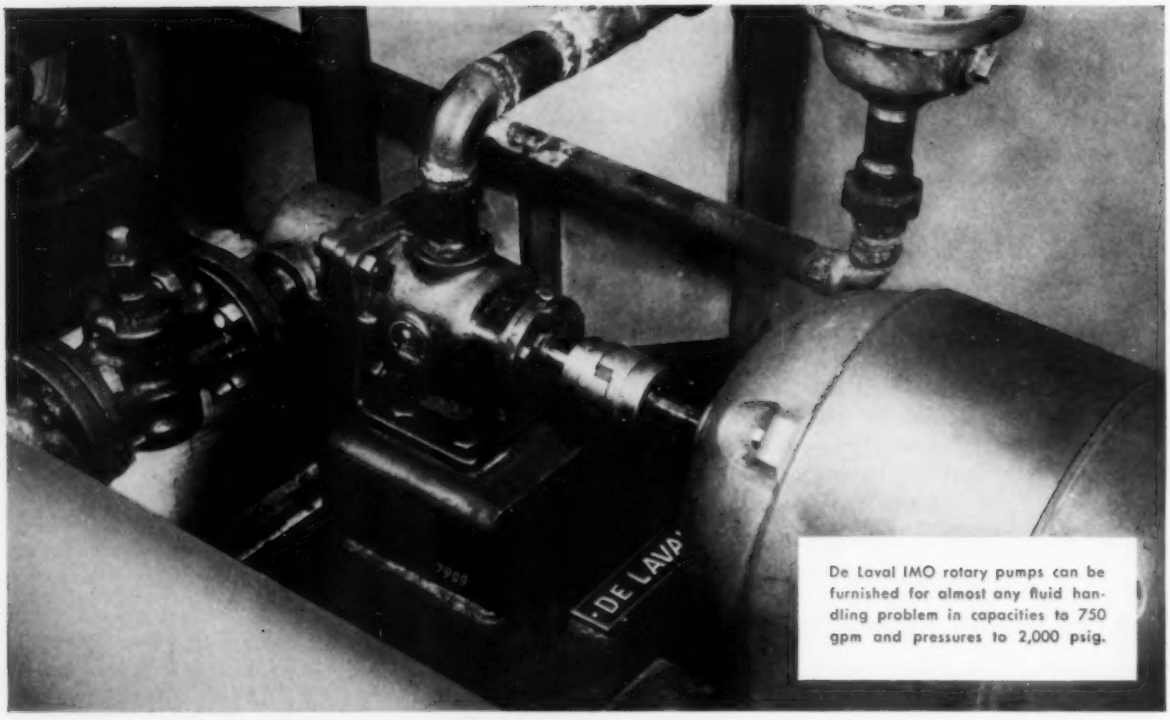
HARVEY Aluminum

Harvey is a leading independent producer of quality aluminum products in all alloys and sizes: Rod and bar, pipe, tube, hollow sections, press forgings, forging stock, impact extrusions, structurals, special shapes, extrusions, screw machine products and other aluminum products. Harvey is also producing similar items in titanium and steel.



De Laval IMO rotary pumps can be furnished for almost any fluid handling problem in capacities to 750 gpm and pressures to 2,000 psig.

What to Look for in a Rotary Screw Type Pump

By W. J. MONCON, *Assistant Chief Engineer*
De Laval Steam Turbine Company

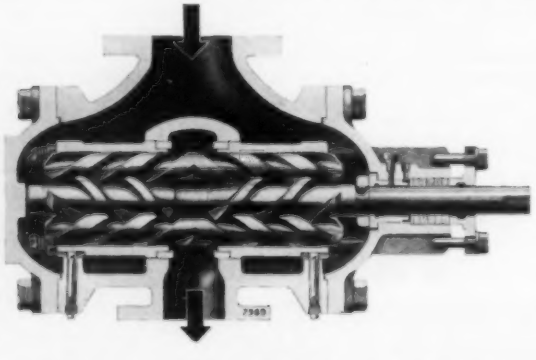
A sound knowledge of design, and how it affects performance, is the best insurance a buyer can have that he will get the pump he needs. This brief analysis of the IMO, a rotary three-screw pump manufactured by the De Laval Steam Turbine Company, will give you some of the necessary facts.

What qualities should you look for in a rotary type pump? It must, of course, meet specified capacities and pressures. But, it must also be efficient, operate quietly, stay on the job.

The axial flow of a screw type pump, and the resulting low inlet losses for any given pump speed, are important benefits that should be considered in making pump selections. The absence of timing gears and other mechanical features of construction also enable the De Laval IMO pump to operate at direct-connected motor and turbine speeds . . . to handle viscous liquids and high suction lifts.

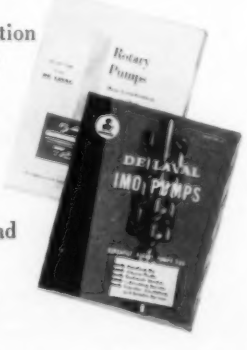
One of the most important features of the IMO pump is the hydraulic turning of the idler or sealing rotors. The central or power rotor is the pumping element; the liquid pumped turns the sealing rotors.

A screw type pump is well suited for applications where pulsation-free flow is desirable. The axial flow of the liquid without trapping and the unique thread form which keeps closures fluid-tight contribute to quiet operation of the IMO pump.

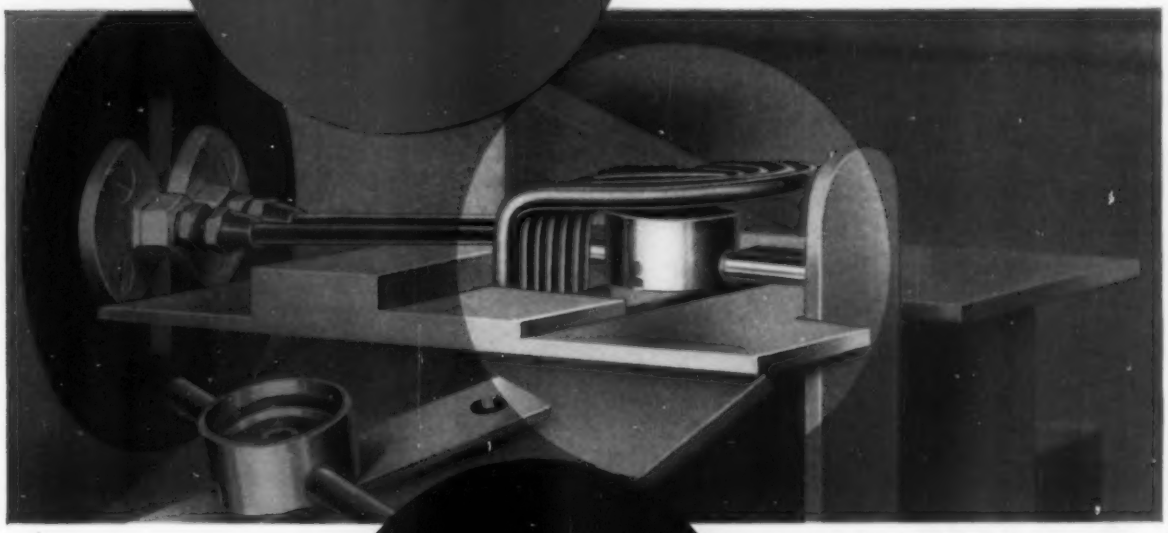


This is a cross-section of the De Laval IMO Series A322A, a positive displacement rotary screw type pump.

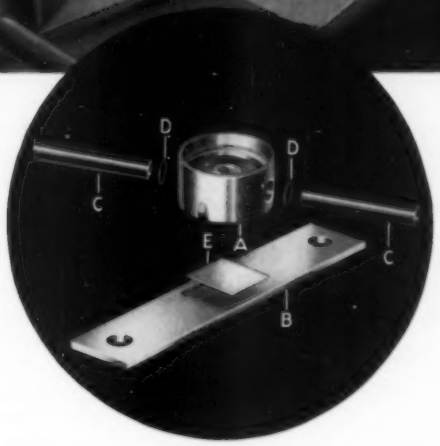
Catalog LS gives useful application and specification data on the IMO pump. An article titled, *Rotary Pumps, Basic Considerations in Their Application*, contains a description of rotary pumps in general. For these publications, write on your company letterhead to De Laval Steam Turbine Company, 801 Nottingham Way, Trenton 2, New Jersey. DL-301



PHOSON SIMULTANEOUSLY BRAZES 3 GAS-TIGHT JOINTS IN 60 SECONDS



Assembly in position for induction brazing, and fully brazed assembly in slide off cooling position.



This bypass valve, for use with a telephone cable pressurization program, was designed for *strength, gas-tightness, corrosion resistance, long life* and *mass production.*

Here's what the problem involved: a brass machined hub (a) had to be fastened to a plate (b) and two copper tubes (c) fastened to the hub. Because the finished joints had to embody all the requirements of the base materials, low temperature brazing with Phoson and Sil-Flux was chosen. Two Phoson rings (d) ¼" ID x .031 wire and a Phoson shim (e) ¾" square x .003 were specified. By induction brazing with Phoson and Sil-Flux, the four parts were joined simultaneously in just 60 seconds!

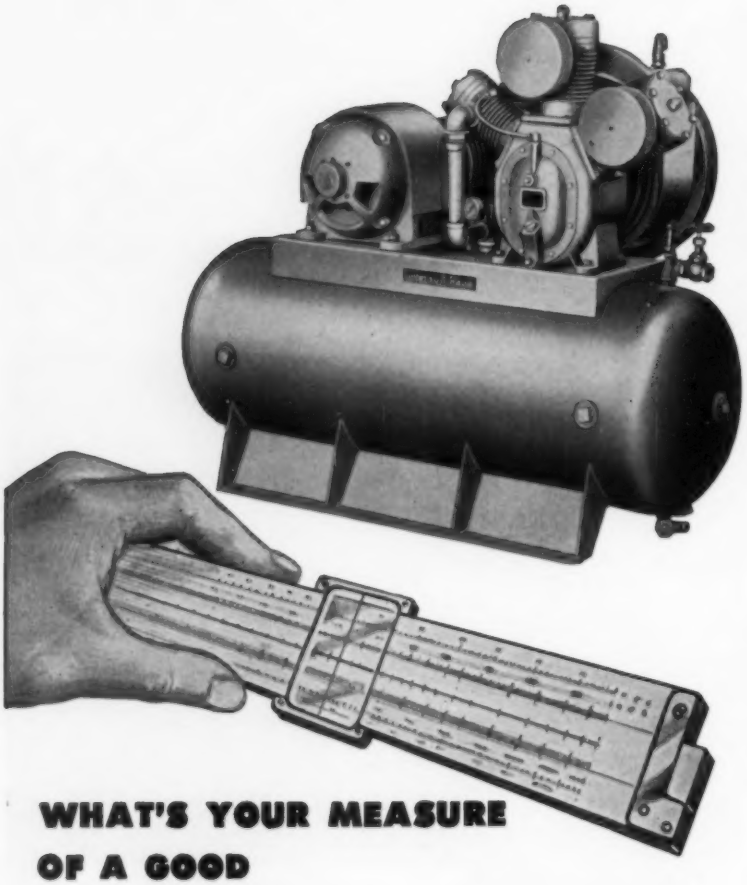
For dependable, economical mass production metal joining, with *highest* possible strength at *lowest* practical temperatures, specify L.T.* brazing — and for L.T.* brazing alloys . . . specify the best: Phoson or Sil-Bond with Sil-Flux.

*Low Temperature

CALL YOUR UNITED WELDING SUPPLY DISTRIBUTOR

UNITED WIRE AND SUPPLY CORPORATION

PROVIDENCE 7, R. I. OFFICES IN PRINCIPAL CITIES



WHAT'S YOUR MEASURE OF A GOOD

Air Compressor?

Size for size—feature for feature—you'll do well to compare the many advantages the Ingersoll-Rand Air Compressor offers your product:

- Produces more air-per-horsepower because of design features not found in other compressors.
- Operates quietly and efficiently.
- Outlives other compressors—years longer than most as the record shows.
- Looks like Quality—and it is—compact, well constructed, durably built.

Get more detailed information on I-R Air Compressors—½ to 20 hp—and see how they can help the sale of your own equipment. For prompt response, write to:

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3-351 11 Broadway, New York 4, N. Y.

brication. This appears to occur when the minimum oil-film thickness equals the sum of the predominant-peak surface roughnesses of the mating journal and bearing surfaces measured in the circumferential direction after run-in.

The minimum coefficient of bearing friction occurs at a minimum oil-film thickness slightly less than the minimum hydrodynamic oil-film thickness.

Minimum oil-film thicknesses substantially less than the minimum hydrodynamic oil-film thickness are indicative of coefficients of bearing friction higher than the minimum possible value or in most cases even higher than that corresponding to the minimum hydrodynamic oil-film thickness.

Abstracted from "Surface Roughness," by L. F. Kreisle, Assistant Professor of Mechanical Engineering, University of Texas, Austin 12, Texas, Paper No. 56-LUB-5 presented at ASME-ASLE Lubrication Conference, Oct. 8-10, 1956, Atlantic City, N. J.

Frequency Response of Pneumatic Transmission Lines

The experimental results attest to the advantage of using the larger tubing sizes. For example, when using 200 ft of ½ in. tubing there is almost no loss of amplitude, even at frequencies approaching 10 cps. However, the output amplitude shows a cyclic variation with frequency which should probably be taken into account when designing a system, although the cyclic nature would possibly be greatly reduced with an end volume connected to the tube.

By far the greatest advantage of the larger tubing sizes is the partial elimination of amplitude reduction. The larger tubing also shows some tendency to reduce the phase lag, although not too much difference can be noted in this respect between the different tubing sizes.

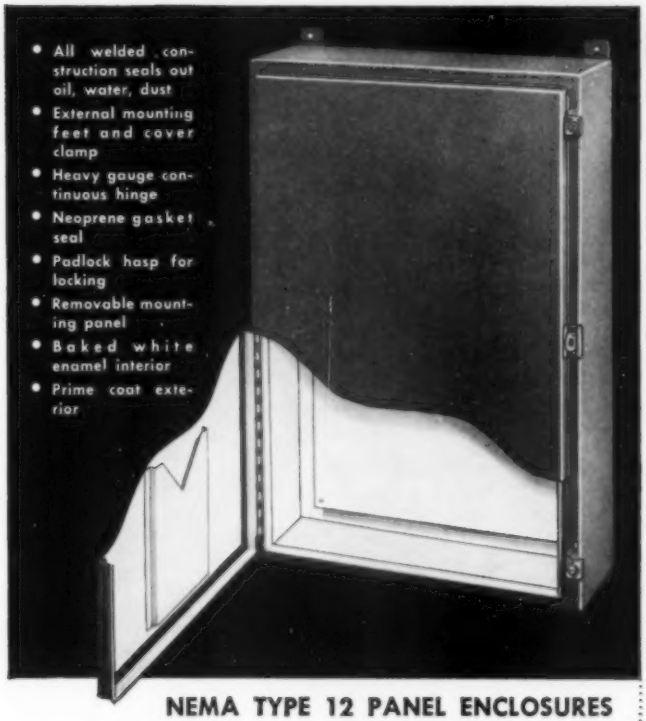
The experimental results can be approximated at the lower frequencies by use of equations for an electrical circuit involving distributed resistance and capacitance. This type of analogy works well with the small tubing but shows increasing deviation from the experimental results as the tubing diameter increases.

The results can be approximated in a somewhat better fashion with the

(Continued on page 325)

Which of these oil-proof enclosures can you use right now?

Write us


• All welded construction seals out oil, water, dust
• External mounting feet and cover clamp
• Heavy gauge continuous hinge
• Neoprene gasket seal
• Padlock hasp for locking
• Removable mounting panel
• Baked white enamel interior
• Prime coat exterior

NEMA TYPE 12 PANEL ENCLOSURES

These panel enclosures are strong, rigid and cleanly finished. All welded construction on heavy gauge steel. No knockouts or holes to admit oil, water, dust. Stock sizes at low cost for fast delivery. Or we can make any size you want. Illustrated above is wall cabinet type. We also make a *floor mounted 2-door series* in the following sizes: 54x42x8, 60x48x8, 60x48x10, 60x60x10, 72x60x10.

STANDARD STOCK SIZES, SINGLE DOOR, WALL MOUNTED

16 x 12 x 6	30 x 20 x 6	30 x 24 x 8	42 x 36 x 8
20 x 16 x 6	30 x 24 x 6	36 x 24 x 8	48 x 30 x 8
20 x 20 x 6	36 x 24 x 6	36 x 30 x 8	48 x 36 x 8
24 x 20 x 6	24 x 24 x 8	42 x 30 x 8	60 x 36 x 8

WE SPECIALIZE IN HIGH QUALITY SHEET METAL ENCLOSURES OF ADVANCED DESIGN

Here are some of the Hoffman boxes that the trade likes so well today. We build them strong and give them a smart, clean finish. Customers like them so well we've had to double and then redouble our production space. Why not look at a sample? You'll see why.

All of these models comply with J. I. C. specifications and come in a wide range of sizes. They are stocked by selected electrical wholesale distributors—fast service. But we can make any special size you need to fit your specifications. Tell us your problem—we can work it out.

Improved
J. I. C. WIRING BOXES

Oil-proof
Dust-proof

4 x 4 x 3
6 x 4 x 3
6 x 6 x 4
8 x 6 x 3½
10 x 8 x 4
12 x 10 x 5
14 x 12 x 6
16 x 14 x 6

Fourteen gauge steel, welded seams, all sides flanged. Neoprene gasketed cover chained to box, clamps on tight, opens up easily. No screw holes to leak oil or water. Clamp screws captivated, cannot get lost. Available with or without removable panel. Eight standard sizes.

Need a little one like this?

2" WIRING BOXES

This is a unique small box which may be just what you are looking for. Completely oil-tight and dust-proof. Neoprene gasketed cover. Cover screws thread into the box outside the gasket line. Available with or without mounting feet. Stock size 4 x 2 x 2, or other sizes on specification.

PUSHBUTTON BOXES

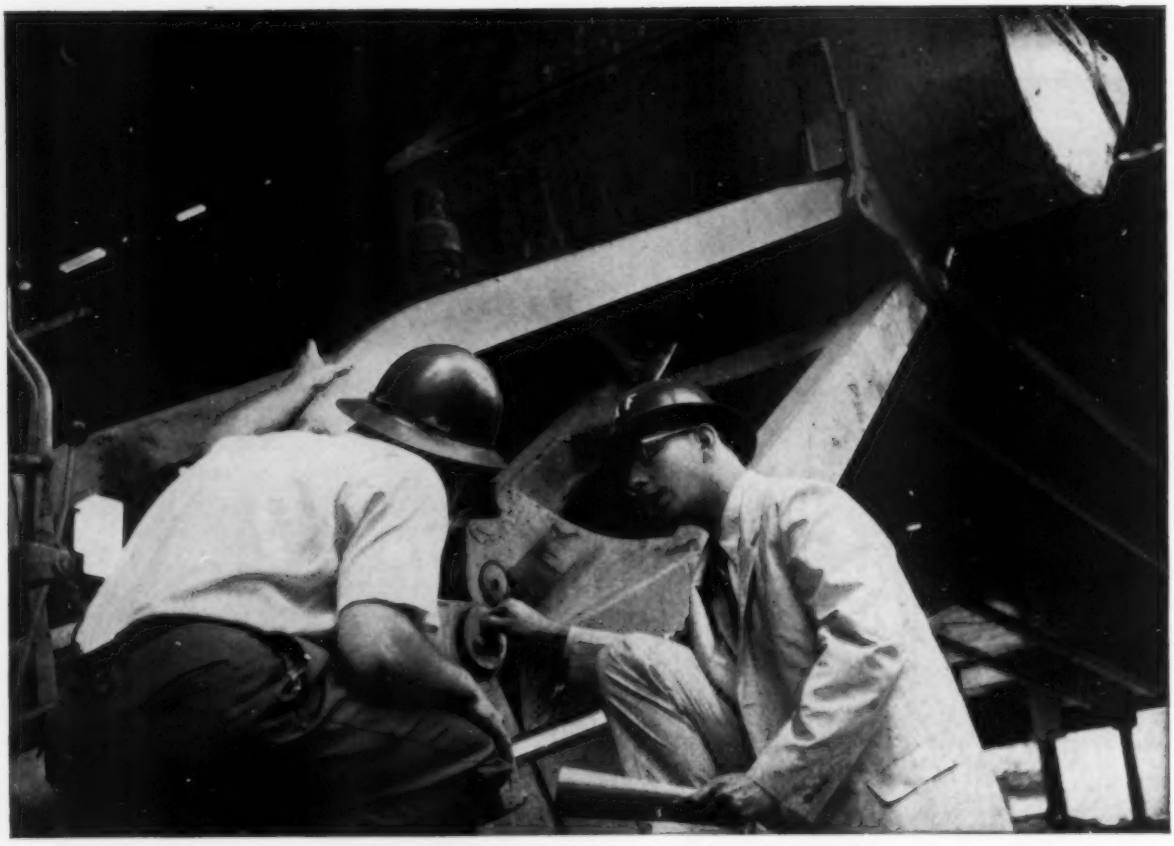
Patented openings will fit all standard makes of oil-tight units. Conduit connections can be made at any location you specify. Neoprene gasket provides positive cover seal. This type is made of 14 gauge steel, and is immediately available in ten standard sizes to accommodate from one to twenty-five push buttons. Cost is surprisingly low.

J. I. C. WIRING TROUGHS

Ideal for electrical wiring on machinery, in buildings, and outdoors where oil, dust, dirt or water is a problem. All seams welded, no holes in trough or cover. Gasketed clamp cover provides tight seal. Eight standard sizes ranging from 2½ x 2½ x 12 to 4 x 4 x 72. Special sizes on request.

***Note:** These troughs are also available with flanged ends and fittings that can be bolted together to make a continuous oil-tight wireway.*

Hoffman ENGINEERING CORPORATION
Dept. PE-62, Anoka, Minn. Phone Harrison 1-2240



Why the trend to heat-treated cap screws in the heavy equipment industry?

Chicago Screw engineers worked with leading manufacturers to develop the high-strength, heat-treated screws that take more punishment and greatly reduce fastener costs

Strength, and the ability to withstand severe punishment, are prime requirements for fasteners used in heavy equipment. As a leading fastener source for most of the top manufacturers of heavy equipment, CHICAGO SCREW conducts a thorough research and development program aimed at steadily improving fastener performance.

A major result of this program is the development of the CHICAGO *carbon-restored* heat-treated cap screw, now replacing bright-finish fasteners for most heavy equipment applications. Design engineers have found the far greater tensile strength of the heat-treated fastener (see chart) gives a better fastening with fewer—or smaller—screws. This means less weight . . . and a considerable reduction in fastener costs.

In addition to greater strength, CHICAGO heat-treated cap screws prove far superior in withstanding fatigue, wear, shock and vibration. This is because a major cause of fastener failure—a surface layer of soft, decarburized steel—is eliminated by our unique Carbon Restoration process. Vital surface carbon is restored in a scientifically controlled process during final heat-treating, producing a fastener that's uniformly hard from core to surface.

Our engineers will be glad to advise you on designing to best take advantage of heat-treated cap screws. For complete information on cost savings you can get in your products . . . and a detailed version of the condensed tensile strength chart at right . . . drop a line to our Standard Products Division.

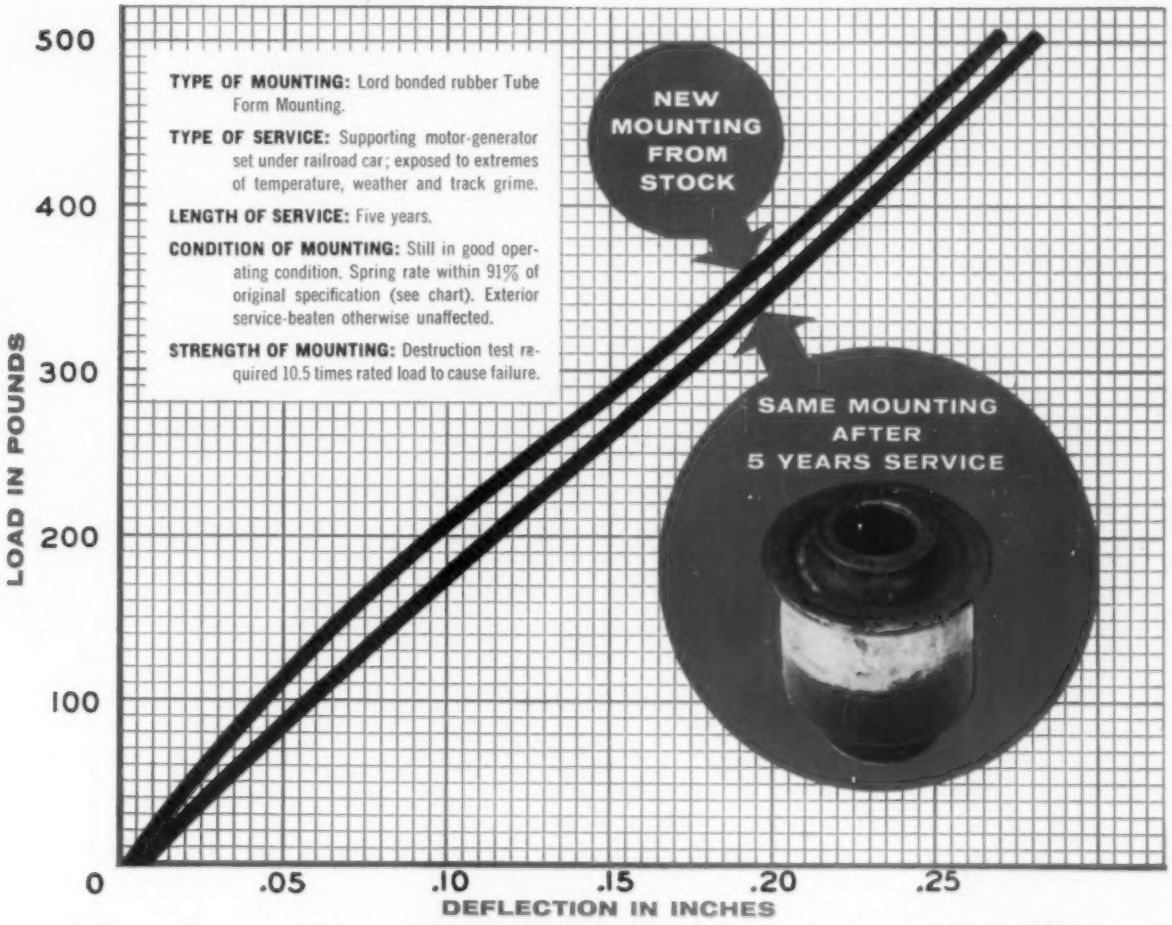
HOW TENSILE STRENGTH COMPARES

Diameter (Coarse Thread)	Bright Cap Screws Tensile Strength (Pounds)	Heat-Treated Cap Screws SAE Grade 5 Tensile Strength (Pounds)
¼	2,150	3,810
5/16	3,550	6,270
3/8	5,250	9,280
7/16	7,200	12,720
½	9,650	17,000
9/16	12,400	21,800
⅝	15,400	27,070
¾	21,400	40,100
⅞	29,500	53,040
1	38,700	69,590

THE CHICAGO SCREW COMPANY

DIVISION OF STANDARD SCREW COMPANY • ESTABLISHED 1872
2507 WASHINGTON BOULEVARD, BELLWOOD, ILLINOIS

what is the life expectancy of a LORD vibration mounting?


500
400
300
200
100
0
LOAD IN POUNDS
.05
.10
.15
.20
.25
DEFLECTION IN INCHES
TYPE OF MOUNTING: Lord bonded rubber Tube Form Mounting.
TYPE OF SERVICE: Supporting motor-generator set under railroad car; exposed to extremes of temperature, weather and track grime.
LENGTH OF SERVICE: Five years.
CONDITION OF MOUNTING: Still in good operating condition. Spring rate within 91% of original specification (see chart). Exterior service-beaten otherwise unaffected.
STRENGTH OF MOUNTING: Destruction test required 10.5 times rated load to cause failure.
NEW MOUNTING FROM STOCK
SAME MOUNTING AFTER 5 YEARS SERVICE

►*five-year service results in little change in isolation efficiency*

How long do LORD bonded rubber mountings retain their excellent vibration isolation characteristics?

Recently, LORD had an opportunity to test a mounting which had been exposed to five years of rigorous service. The remarkable results shown above are a convincing demonstration of the extra-long life of LORD mountings.

This was not an exceptional case, but is typical of the continuous, long-term effectiveness of all LORD products. It is the planned result of (1) the careful design of the contour of the flexing element to provide uniform stress distribution, (2) a rubber-to-metal bond of unsurpassed strength and permanence and (3) elastomers which are specially selected and custom-compounded for each job. And LORD engineers are constantly striving to build even more life into LORD mountings.

The like-new performance of LORD mountings even after long, rugged service means much in terms of lower lifetime costs, fewer mounting replacements, and greater safety.

When you have a problem in vibration control, it makes sense to bring it to LORD—the leader in engineering vibration control and bonded rubber products. Contact your nearest LORD Field engineer or the Home Office, Erie, Pa.

LORD
BONDED RUBBER

designers and producers of bonded rubber products since 1924

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MORE EFFICIENT DESIGN, IMPORTANT SAVINGS, SIMPLIFIED ASSEMBLY, BETTER APPEARANCE

These are some of the many benefits reported by Design Engineers who have adopted TRU-LAY PUSH-PULLS for remote control operations on literally hundreds of products

Here are typical comments recently received from equipment manufacturers whose machines or implements are equipped with these accurate and dependable remote controls:

Saves Time, Labor and Material
"The use of your flexible Push-Pulls saves us a great deal of time, labor and material. The old linkages frequently required much planning in both engineering and shop which is not required now. On some of our equipment we use Push-Pulls from 10 to 30 feet in length. They operate clutch controls on the Main Power Unit, Feed Conveyors and Delivery Conveyors."

Greater Flexibility of Design
"The principal advantage of Tru-Lay Push-Pulls in our application is that they permit flexibility in locating the control valve in relation to the operator's position."

Cost Less to Install
"Tru-Lay Push-Pulls are easier and less expensive to install than linkages for remote control of power take-off, brake and clutch. Better appearance, too."

Simple and Neat
"For several models of farm tractors, we selected your controls for their simplicity and neatness of application as governor controls."

Solution to Tough Problem
"Can be installed where straight rods are impossible . . . for Remote Control of transmissions, brakes and clutches."

Eliminates Maintenance
"Simple operation and elimination of maintenance problem are the major advantages in using your Push-Pulls."

Reduces Number of Parts
"Your Push-Pulls have eliminated links, radius rods and other lost-motion devices for remote control of hydraulic valves."

Provide ACCURATE Control
"Tru-Lay Push-Pull control cables provide minimum back-lash, even in installations up to 30 feet in length, because the cable is designed to close tolerances with minimum drag and lost motion."

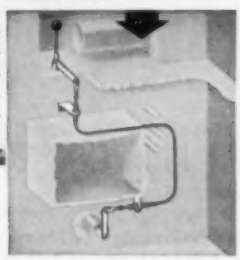
• • •

TRU-LAY PUSH-PULLS are "Solid as a rod but *Flexible* as a wire rope." This flexibility makes it possible to snake around obstructions . . . permits the ideal arrangement of all elements of remote controls.

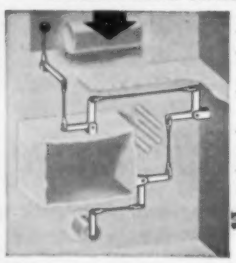
Advantages *of Tru-Lay Push-Pull flexibility and simplicity are pictured below—*

TRU-LAY PUSH-PULL

Simple
One Moving Part
Life-Time Service
Life-Time Accuracy
Low over-all Cost
Noiseless



MECHANICAL LINKAGES



Complex
Many Parts
Many Points of Wear
Increasing Back-Lash
Loss of Accuracy
Vibration
Rattles

Construction Equipment and **Farm Implements** provide good examples of the wide-spread use of these accurate, simple and dependable Push-Pulls. On Power Shovels, Winches, Graders, Road Oilers, Dump Trucks, Snow Plows, Engine-driven Pumps, Crushers, Tractors, Combines, Corn Pickers, Corn Row Sprayers, Corn Detasslers, Orchard Sprayers, Power-driven Tree Trimmers, Tobacco Picking Machines and others . . .

TRU-LAY PUSH-PULLS are operating unfailingly for the remote control of Hydraulic and Air Valves, Brakes, Clutches, Transmissions, Throttles, Chokes, Governors, Power Take-Offs, Spray Nozzles, Vent Directional Fins and on many other applications.

ACCO *Our DATA FILE will answer all further questions*

AUTOMOTIVE and AIRCRAFT DIVISION
AMERICAN CHAIN & CABLE

601-E Stephenson Bldg., Detroit 2
2216-E South Garfield Ave., Los Angeles 22 • 929-E Connecticut Ave., Bridgeport 2, Conn.

There is No Worry about Failures or Maintenance Costs with TRU-LAY Push-Pull Remote Controls

Long Life is a matter of record. We have never heard of a Tru-Lay Flexible Push-Pull Control wearing out in normal service. Failures, that sometimes harass users of more complex controls, are eliminated by the use of these simple, positive-action controls.

Dependable Operation of these controls is a certainty, even under the most adverse conditions . . . HOT as jet engines (note: Tru-Lay Push-Pulls are actually performing on hot jet applications) . . . COLD to 70° F below zero . . . SOAKIN' WET . . . ABRASIVE . . . or just plain TOUGH.

Freedom from Trouble is assured because of such features as . . . full protection of the inner, working member by the tough flexible conduit . . . lubrication of the inner, working member *for life* during assembly . . . seals that keep moisture, dust and other foreign matter out of the unit . . . cold swaging of fittings that makes them integral parts of the control unit.

Accuracy is inherent in the basic design of Tru-Lay Push-Pulls. They are precision products, not gadgets.

Capacity ranges from light jobs up to jobs of 1,000 lbs. input. These Push-Pulls will handle jobs 150 feet or more from the control point.

"Solid as a rod, Flexible as a wire rope" aptly describes Tru-Lay Push-Pull Controls. This flexibility provides positive, remote action whether anchorages are fixed or movable . . . it damps out noise and vibration . . . it greatly simplifies installation of controls by reducing the number of working parts and by making it possible to snake around obstructions.

Adaptability to all sorts of mechanical situations explains, in large measure, the wide-spread application of Tru-Lay Push-Pulls. Standard anchorages, fittings and heads have been designed that meet requirements on approximately 80% of the installations. Simple modifications of these standards, or minor changes in your own design, cover almost every special situation. Our engineers have the know-how on such matters, and will work with you.

For Further Information—The DATA FILE pictured at the left contains six booklets and bulletins that will answer any further questions you may have about this versatile and dependable tool. It is quite likely that this material will point the way to a simplified solution of your remote control design problems. **Write for a copy.**

theory derived by Iberall. However, his results show only approximate agreement and this only at the lower frequencies. At the higher frequencies or when using large input amplitudes, it appears that experimental data are still necessary to obtain accurate results.

Abstracted from "Frequency Response of Pneumatic Transmission Lines," by R. P. Sandell, Standard Oil Co. of California and N. H. Ceaglske, University of Minnesota, *ISA Journal*, Dec. 1956.

Nickel Electroforming

New forms may be produced or existing ones reproduced by electrodepositing nickel on a removable mold or pattern.

Degree of adhesion of deposited metal is smaller, while thickness of deposit is greater than in plating.

Final machining and grinding of electroformed nickel parts is often necessary.

Advantages of the process include ability to produce intricate shapes, maintenance of close tolerances, accurate reproduction of fine detail, integral construction. Limitations are high cost, high rejection rates and small production runs.

Steps of the process are described.

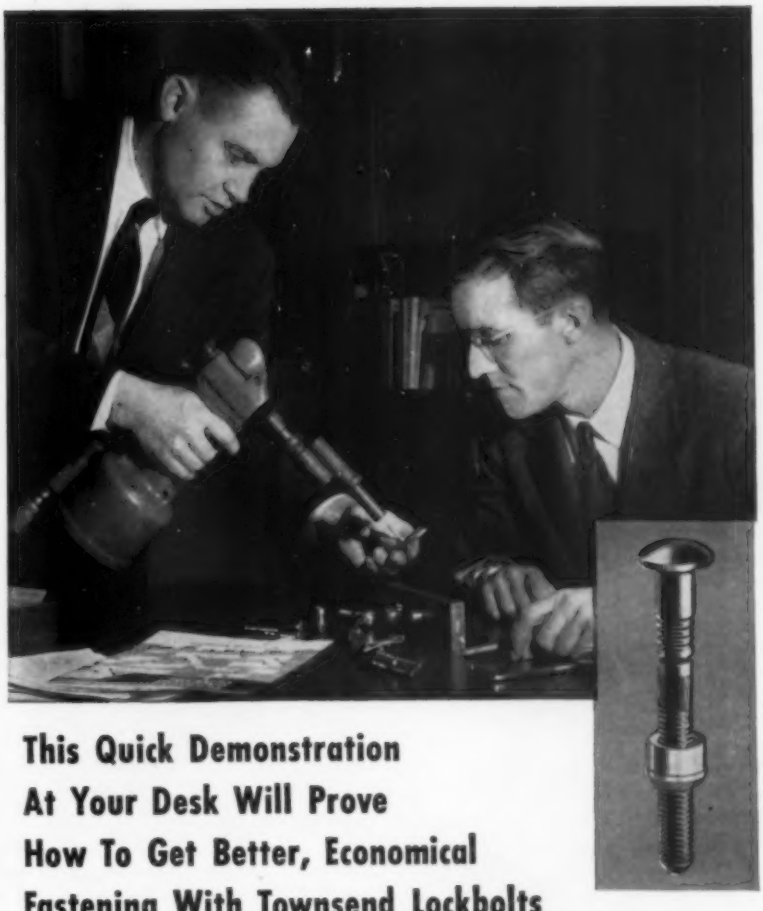
Abstracted from "Nickel Electroforming," by Dodd S. Carr, Bart Mfg. Corp., Belleville 9, N. J., Plating, Dec. 1956.

Torsional Stiffness of Thin-Walled Shells

A theoretical investigation has been made of the Saint-Venant torsion of certain composite bars. These bars are composed of two materials—one material in the form of a thin-walled cylindrical shell and the other material in the form of a core which fills the interior of the shell and is bonded to it.

An approximate boundary-value problem is formulated on assumptions similar to those of the theory of torsion of hollow thin-walled shells (Bredt theory). This boundary-value problem is solved exactly for a rectangular cross-section and approximately for slender triangular and slender diamond cross-sections. The approximate solutions are obtained by the use of two energy procedures. Re-

(Continued on page 328)



This Quick Demonstration At Your Desk Will Prove How To Get Better, Economical Fastening With Townsend Lockbolts

A few minutes of your time invested in watching a simple demonstration of a better fastening method may point the way to savings of thousands of dollars in assembly of your products. The Townsend lockbolt provides a quick method of producing tight, rigid fastenings that cannot loosen even under extreme vibration or shock conditions.

We would like to have a Townsend engineer demonstrate to you and others in your organization how these lockbolts combine the advantages of riveting and bolting—eliminate the disadvantages. He will show you that installation is fast—that fewer workers can complete an assembly in less time—you improve your product—achieve a lower installed cost.

You will be able to see why the clamping action, or clinch, of Townsend lockbolts is higher than rivets—is more uniform than bolts and nuts. The demonstration will explain how the lockbolt fills the hole better than other fasteners—makes possible a more rigid joint and provides an effective liquid seal.

Townsend lockbolts are available in steel and aluminum alloy, in 3/16", 1/4", 5/16" and 3/8" diameters, in grip length ranging up to 2", in various head styles.

For a demonstration on how to speed production, get tight, secure, permanent fastening with Townsend lockbolts write on your company letterhead to Townsend Company, P.O. Box 237-D, New Brighton, Pa.

Licensed under Huck patent nos. RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049; 2,754,703

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TAYLOR Laminated Plastics Vulcanized Fibre

Shop Talk

TAYLOR FIBRE CO.

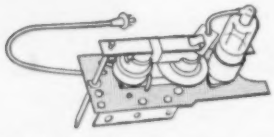
Plants in Norristown, Pa. and La Verne, Calif.

PHENOL—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • COPPER-CLAD LAMINATES • VULCANIZED FIBRE

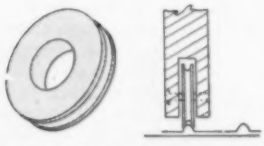
Tips for designers

Aircraft fuel gage tank unit uses a tube of Taylor epoxy glass base laminate . . . an unusual material noted for excellent corrosion resistance and electrical insulation over a wide humidity range.

Welders' helmets are fabricated from tough durable Taylor vulcanized fibre . . . readily formed to many desired contours.



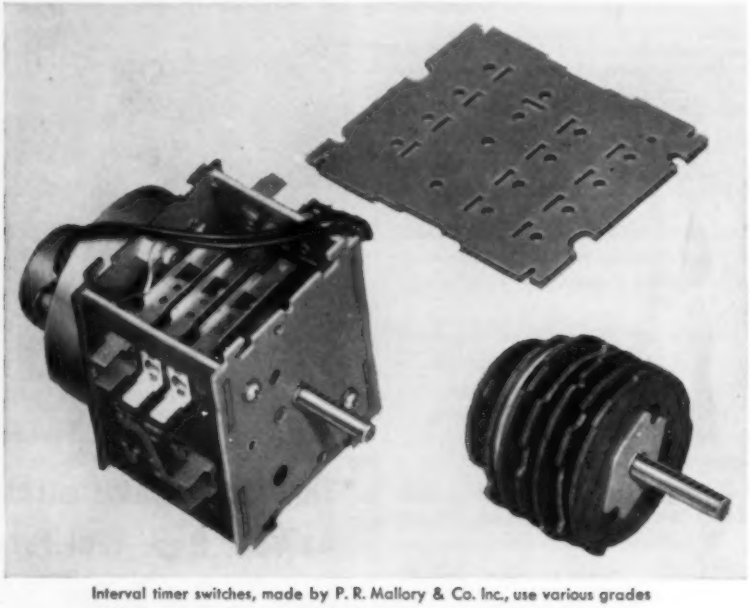
Base plate for high-voltage TV component, punched from Taylor canvas melamine laminate, has high dielectric strength and arc resistance.



Rollers for flush doors are now being made from Taylor paper base tubing with ball bearing insert . . . providing smooth, silent operation at a low cost.

NEW TAYLOR COPPER-CLAD LAMINATES

Taylor GEC (glass-epoxy) Copper-Clad and Taylor XXXP-242 cold punching (paper-phenol) Copper-Clad. Taylor uses high purity rolled copper on base materials with outstanding electrical properties.



Interval timer switches, made by P. R. Mallory & Co. Inc., use various grades of Taylor paper base phenol laminates for cams and terminal boards. These laminates provide electrical insulation, strength, dimensional stability.

Tough specifications?
check Taylor phenol laminates

Choose from over 30 grades of Taylor phenol laminates, for the combination of electrical, physical, and machining properties you want. These rugged, versatile laminates can meet your most demanding specifications, improve end-product performance . . . and bring you major savings in material and fabrication costs.

These laminates, consisting of a paper, cotton fabric, asbestos, glass cloth or nylon base impregnated with Phenol resins, were developed to meet the need for dependable, moisture resistant insulation. They possess high dielectric and mechanical strength. Unaffected by heat or cold (except extremely high temperatures) they resist oils and most chemicals, and are especially suited to the punching and machining of accurately-sized parts. Because of their high moisture-resistance qualities, Taylor phenol laminates will not readily warp or become distorted when subjected to alternating wet and dry conditions.

You'll like the way these laminates handle in the shop . . . how they punch and stake cleanly, how they readily machine to hairline tolerances. And you'll like the way they perform in product application, how they retain their original characteristics over long periods of time and under severe operating conditions.

Taylor offers the service of its field specialists to help you choose the grade of material that matches the exact requirements of your application. Check with Taylor now. Write for the general catalog of Taylor materials. And contact your nearest Taylor sales engineer for a discussion of your particular requirements.

Is your tubing bottleneck shown here?

Bundy Engineers and versatile Bundyweld Tubing can beat the knottiest tubing design problem!

If you think it can't be done with tubing, it's a challenge to Bundy. For years, Bundy Engineers have specialized in working with customers and prospects, solving the insolvable. A unique combination of imagination and experience, plus the extreme versatility of Bundyweld Steel Tubing, has paid off again and again.

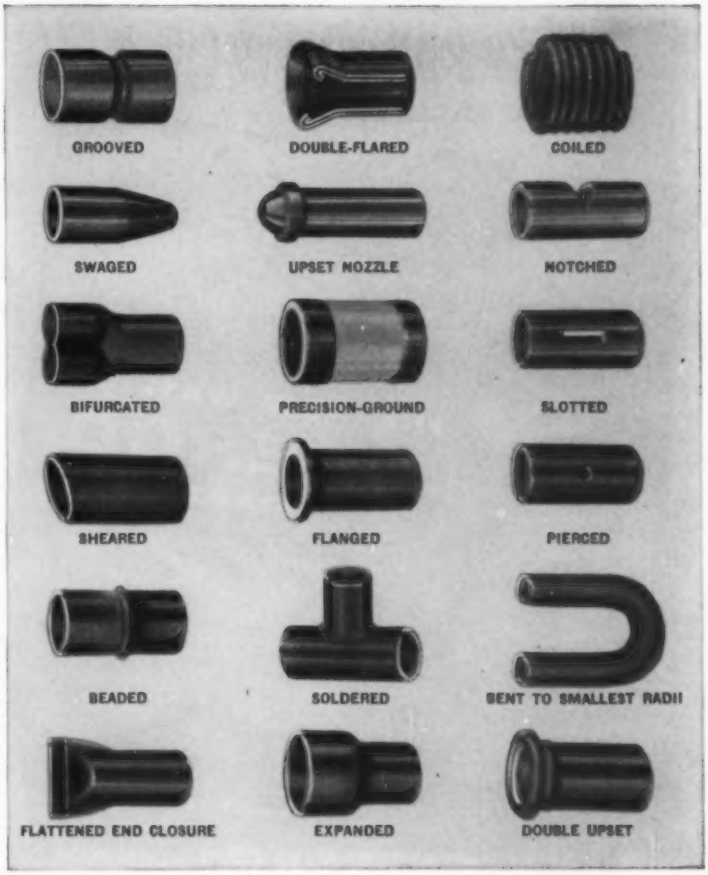
Check first with Bundy for workable solutions to your tubing design problems. Whether you are in the design, developmental, or application stage of your product, Bundy will be glad to work with you. Hundreds of manufacturers have used this Bundy service to advantage.

Bundyweld Tubing offers an unusual combination of properties: high thermal conductivity; high bursting strength; ease of fabrication; and thinner-walled, yet stronger composition. It is the safety standard of the refrigeration industry, and is used in 95% of today's cars, in an average of 20 applications each.

Call, write, or wire us today!

BUNDY TUBING COMPANY

DETROIT 14, MICHIGAN



Shown above are but a few of the fabrication operations which are possible with Bundyweld Steel Tubing. Many of these, and others not shown, were developed through solving a specific problem brought to us by a customer or prospect. Bundy invites you to avail yourself of this design service.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, ITALY, AND GERMANY

Bundyweld starts as a single strip of copper-coated steel. Then it's

. . . continuously rolled twice around laterally into a tube of uniform thickness and passed

through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

Learn all about the NEW
FIREROD®
CARTRIDGE HEATING UNIT
Write for your FREE copy!
ask for bulletin 360

WHERE it can fit into *your* design needs that call for high heat concentration in a small amount of space.

WHAT actual tests prove about the FIREROD'S superiority in high temperature potential and long operating life.

HOW to determine watts densities, temperature control points for your installation.

ALSO charts, tables, illustrated units.

WATLOW
SINCE 1922—DESIGNERS AND MANUFACTURERS OF ELECTRIC HEATING UNITS
ELECTRIC MFG. CO.
1392 FERGUSON AVE.
SAINT LOUIS 14, MO.

sults for the torsional stiffness constants are presented graphically. These methods may be applicable to other cross-sections of practical interest. The choice of approximate method for any particular problem depends on the range of parameters involved.

The stiffness obtained by the simple procedure of adding together the individual stiffnesses of the core and the hollow shell (neglecting the effect of the bond) yields results less than 5 per cent low for rectangular cross-sections. For slender triangular and diamond cross-sections this elementary approximation is generally not so good and in certain cases it yields results which are considerably low.

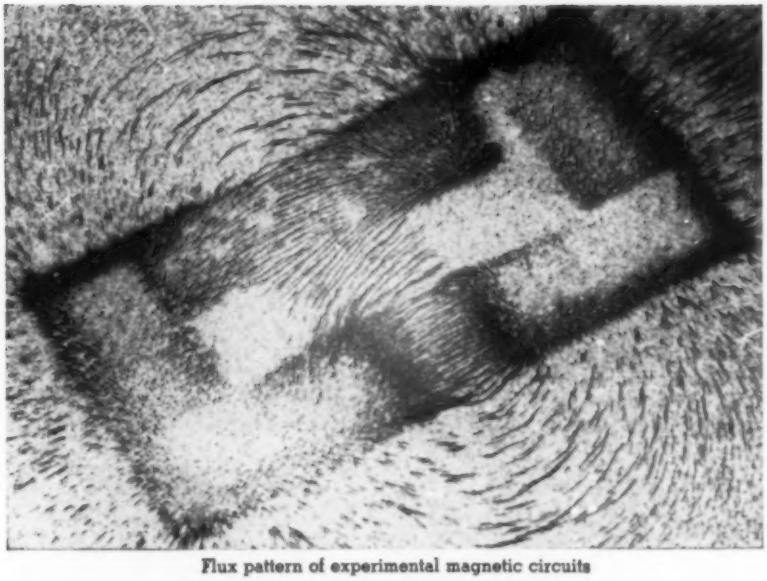
Abstracted from "Torsional Stiffness of Thin-Walled Shells Having Reinforcing Cores and Rectangular, Triangular, or Diamond Cross Section," by Harvey G. McComb, Jr., Langley Aeronautical Laboratory, Langley Field, Va., NACA Technical Note 3749, Oct. 1956.

Problems in Standardizing Electrical Per Unit Quantities

In furthering its aim of establishing a universally accepted language for describing rotating machine phenomena, the Rotating Machinery Committee of the AIEE has created a working group on definitions of per unit quantities. Discussions at several meetings of this working group have clearly indicated problems in standardizing the definitions of per unit quantities. This paper delineates the problems for the purpose of eliciting discussion from anyone interested in order to help the working group arrive at recommended definitions.

Since a per unit value is the actual value of the quantity divided by a base value, the definitions of the base values are fundamental. Rotating machines are devices for converting mechanical energy to electrical energy, or vice versa, hence, base units are desired for each kind of energy. Unfortunately, relationships between these two energies involve power factor and efficiency, which are not fundamental quantities and may vary considerably under the influence of such factors as marketing policy, manufacturing procedures and other "non-technical" reasons. Consequently, it has become

(Continued on page 332)



Flux pattern of experimental magnetic circuits

How location of magnets affects magnetic circuits

Adapted from an article by Charles A. Maynard, vice president, Research and Engineering, The Indiana Steel Products Company

The LOCATION of permanent magnets in a magnetic circuit is a definite factor in design. To determine the extent to which this is true, involved calculations are necessary.

A comparatively simple experiment, however, which shows the nature of the changes that take place when permanent magnets are placed in different positions in a magnetic circuit, was devised by Mr. Maynard. The material on which the following questions and answers are based was taken from a report, "An Experiment in Magnet Location," published in Vol. 3, No. 5, of Applied Magnetics. *A copy of this issue is available on request to The Indiana Steel Products Co., Dept. C-2, Valparaiso, Ind.*

Question: What effect does the location of permanent magnets have on a magnetic circuit?

Answer: It has a marked influence on the flux density in the various portions of the magnetic circuit.

Question: Is there a preferred location for magnets?

Answer: Yes, it is important to place the magnets as close to the air gap as possible.

Question: What is the benefit of their location?

Answer: The leakage flux is reduced, and the useful flux in the air gap is increased.

Question: How is this an important factor in design?

Answer: It minimizes the amount of magnet material required to produce a given flux in the air gap.

Question: Does this mean lower magnet costs?

Answer: Generally, this is true. However, structural considerations may prevent the placement of permanent magnets at preferred positions.

Question: Are there available quantitative data which indicate the degree to which magnet position influences the efficiency of a circuit?

Answer: A brief experiment was conducted on the nature and magnitude of the changes that occur when magnets are placed in various positions in a simple magnetic circuit. The results are discussed in *Applied Magnetics*, Vol. 3, No. 5.

World's largest permanent magnet separates electron particles

The largest and most powerful permanent magnet ever designed is an important part of a new Mass Spectrometer to be used for high molecular weight hydrocarbon analysis at the Whiting, Indiana, research and development laboratories of a large Midwestern oil company. Function of the spectrometer is to establish a strong magnetic field that separates electron particles.

Indiana's C. A. Maynard inspects air gap of giant Alnico V magnet assembly

The Alnico V permanent magnet used in the assembly has a maximum field strength of 6,000 gauss . . . equal to 10 tons of magnetic holding force . . . and weighs 1,300 pounds. The complete assembly, which weighs approximately 4,700 pounds, was designed and fabricated by The Indiana Steel Products Company, Valparaiso, Indiana.

THE INDIANA STEEL PRODUCTS COMPANY
VALPARAISO, INDIANA

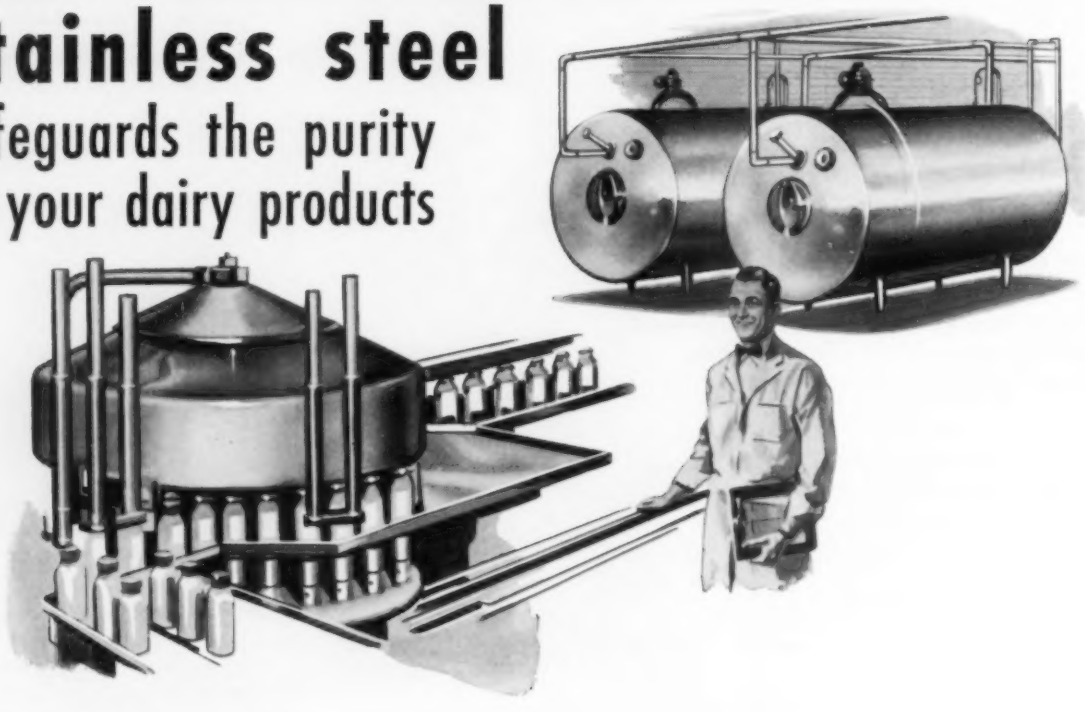
THE WORLD'S LARGEST MANUFACTURER OF PERMANENT MAGNETS

INDIANA PERMANENT MAGNETS

In Canada . . . The Indiana Steel Products Company of Canada, Limited, Kitchener, Ontario

from cow to container...

stainless steel
safeguards the purity of your dairy products



Dairymen and milk-product plant operators know that Stainless Steel is the only metal that year after year effectively resists acid corrosion. It can easily be kept clean and sterile and imparts no odor in contact with the product.

Through all the stages of milking, transportation, processing and packaging Stainless Steel completely safeguards the delicate flavor and highly sensitive qualities of milk and cream, and milk products like butter, cheese, ice cream and powdered milk.

The delicious taste of your dairy products and the assurance of their purity is due to the dairyman's extreme care and scientific methods and the use of Stainless Steel equipment.

McLOUTH STAINLESS STEEL

For the product you make today and the product you plan for tomorrow specify McLouth high quality sheet and strip Stainless Steel

McLOUTH STEEL CORPORATION DETROIT, MICHIGAN • MANUFACTURERS OF STAINLESS AND CARBON STEELS

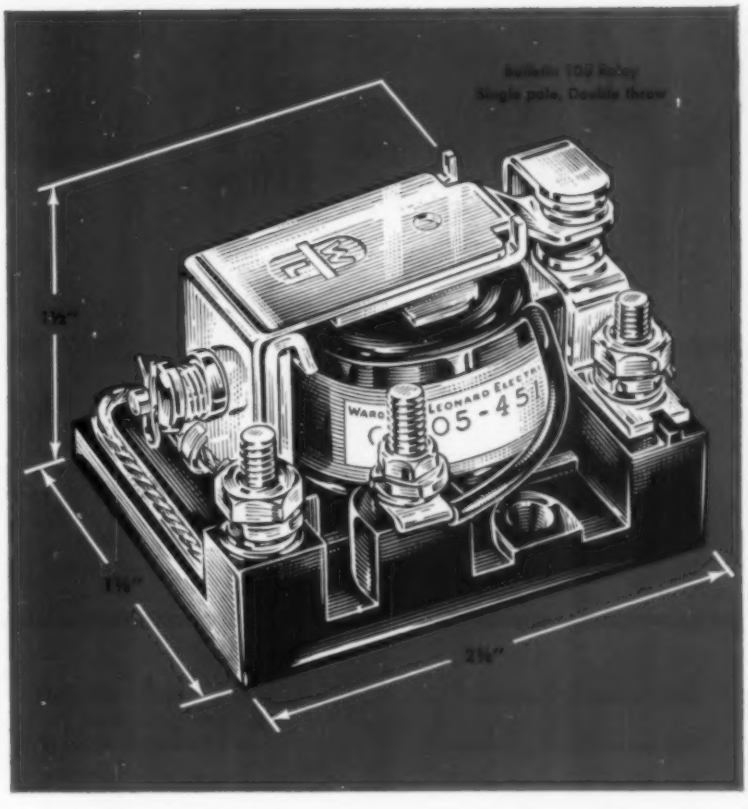
Compact power relay— high contact ratings

More relay for your money—that's the big thing you get when you specify Ward Leonard's Bulletin 105 for light power switching jobs.

No delicate, misapplied telephone- or instrument-type relay, the 105. From rigid phenolic base to ample silver-to-silver, self-cleaning contacts, the 105 is built to deal with *power* . . . just like the larger Ward Leonard relays and contactors. And yet it's extremely compact and low in cost.

You'll find the Bulletin 105 relay—in SPST, SPDT, DPST, and DPDT types—ideal for controlling power to electric heaters, signals, pumps, radio and TV transmitters and public address systems.

Check your catalog file today for Bulletin 105. If it's missing write to: Ward Leonard Electric Co., 63 South Street, Mount Vernon, N.Y. (In Canada: Ward Leonard of Canada Ltd., Toronto.) 7.1



ENGINEERING DATA

SINGLE POLE BULLETIN 105 RELAY

Contact Ratings

Volts	D.C. Amps.* N.O.	D.C. Amps.* N.C.	A.C. Amps.* N.O.	A.C. Amps.* N.C.
0-24	20	15	20	15
25-125	½	½	20	15
126-250	—	—	15	10

*Ratings are non-inductive.

COIL VOLTS: 6, 8, 10, 12, 24, 32, 48, 115, 230
AVG. COIL WATTS: 2 D.C., 3.75 A.C.
PICK-UP: 85% or less of rated voltage
WEIGHT: 5 ounces
TERMINALS: Stud type

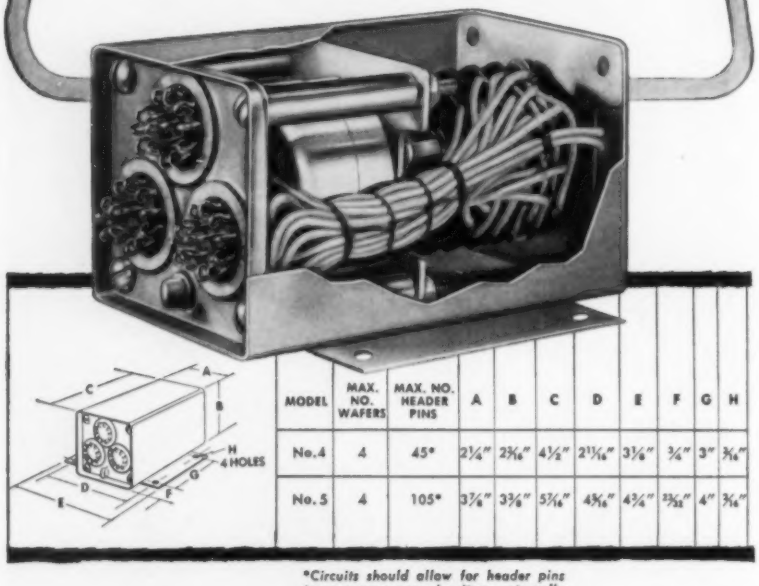
LIVE BETTER...*Electrically*

WARD LEONARD ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

Result-Engineered Controls Since 1892

NEW LEDEX

HERMETICALLY SEALED ROTARY SELECTOR SWITCHES AND STEPPING RELAYS



MODEL	MAX. NO. WAFERS	MAX. NO. HEADER PINS	A	B	C	D	E	F	G	H
No. 4	4	45*	2¼"	2⅜"	4½"	2¹¹⁄₁₆"	3⅛"	¾"	3"	⅜"
No. 5	4	105*	3⅞"	3⅜"	5⅞"	4⅜"	4¾"	2³⁄₃₂"	4"	⅜"

*Circuits should allow for header pins to carry arc suppression items externally

THESE STANDARD HERMETICALLY SEALED ENCLOSURES ARE NOW AVAILABLE FOR LEDEX

Hermetically sealed Ledex switches are moisture-proof, dust-proof and protected from the effects of salt-spray, fungus and humidity. Also, many of the hermetically sealed Ledex selectors qualify for the requirements of MIL-E-5272A. Ledex selectors simplify installation problems, reduce wiring time to a minimum and prevent damage caused by tampering.

Many switching combinations are available with the standard models. If the standard models do not answer your specific requirements, send the salient facts of your special hermetically sealed selector switch problem to us for our recommendations.

For best delivery specify one, ten or fifteen pin headers. (Illustrated)

G. H. Leland INC. WRITE FOR COMPLETE INFORMATION TODAY!

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IN EUROPE: NSF LTD., 31-32 ALFRED PLACE, LONDON, ENGLAND

the practice to use two bases, one for each kind of energy. The electrical base quantities are derived from the rated kva and rated voltage; the mechanical base quantities are usually derived from the rated shaft horsepower and rated speed.

Generator designers employ the kva base, but motor designers are divided into two schools; some, notably synchronous motor designers, advocating the kva base, and others using the horsepower base. Proponents of each system are convinced that their system best serves their purposes. Hence, it seems that both bases should be considered in formulating accepted definitions.

If one set of standard definitions is to be achieved, one group will have to accept a change. There is little doubt that the change will have to be made by the induction machine group, because the system used by synchronous machine people is too universally entrenched in design, analysis and specifications. Advantages of converting induction machine practice will have to be weighed against the disadvantages. The working group solicits comment in the hope of submitting recommendations at the Winter General Meeting.

Abstracted from "Problems in Standardizing Electrical Per Unit Quantities" by R. M. Fisher, Jr., Medium Induction Motor Dept., General Electric Co., Presented at AIEE Fall General Meeting, Oct. 4, 1956, Chicago, Ill.

Current Limiting Fuses and Air Circuit Breakers

True current limiting fuses can be used to protect low-voltage circuit breakers, both thermally and mechanically, from fault currents far in excess of the circuit breaker's interrupting rating. One set of fuses can be used to protect one breaker or a group of breakers.

Good time-current coordination can be obtained between the fuse and circuit breaker in both the overload and fault current ranges. Protection can be provided against single-phasing and possible motor damage due to single-phasing.

Fuse blowing does not cause transient voltages of any great magnitude.

(Continued on page 337)

Unit saves 2¼ man hours on each shaft machined from

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Tips on specifying timer accuracy

Facts you should be aware of when selecting a timer to meet your accuracy requirements

The application for a timer generally determines the kind and degree of accuracy needed.

If frequent changes are made in the timed interval, setting accuracy is most important. If a machine operation or process occurs again and again at the same timer setting, repeat accuracy is the critical factor. If a timer is factory set for, and operates continuously at, one specific interval, inherent timer accuracy is most important.

Each of these three major types of timer accuracy — inherent, setting, and repeat — calls for different design and manufacturing techniques:

INHERENT ACCURACY

A major factor limiting inherent accuracy is the drive motor. This must (1) be quick starting, (2) be free from coasting, and (3) operate only at synchronous speed. Permanent-magnet synchronous motors meet these requirements better than ordinary clock-type hysteresis motors.

Clutching on a high-speed shaft, close to the drive motor, also increases inherent timer accuracy. High-speed clutching—though more complex and costly than low-speed—should be used on timers in which high accuracy is paramount.

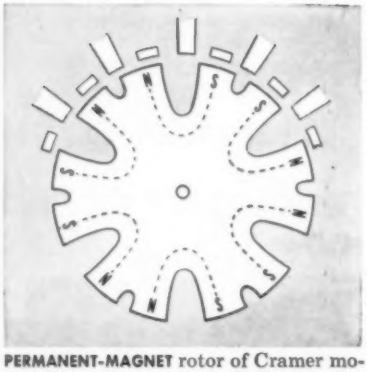
SETTING ACCURACY

Length of dial scale, scale divisions, style of pointers, parallax and distortion due to cover glass, and skill of operators are obvious influences on setting occuracy.

Setting may be of either the friction or vernier (or worm) type. The latter provides good setting accuracies, but lacks the speed and convenience of the friction method. Human errors can often be completely eliminated by use of a factory-set timer.

REPEAT ACCURACY

Shock of operation of a fast reset mechanism — or shock from other causes—can change the timer setting, resulting in inaccurate repeat cycles. This is most likely when the reset and setting mechanisms are combined for reasons of cost. However, by careful design, speed of reset and resistance to shock can be optimized to give the best repeat accuracy.



PERMANENT-MAGNET rotor of Cramer motor (shown here schematically) reaches synchronous speed within two cycles (0.033 sec. at 60 cps) after field is excited, does not coast after power is removed. Most powerful and accurate timing motor available for its size and price.

TECHNICAL HELP AVAILABLE

Cramer field engineers have the answers to most accuracy and other timing problems at their fingertips. They can tell you about Cramer timers with accuracies ranging from 2% to 1/100th of 1% overall. And they'll be glad to discuss your special requirements with you. Get in touch with your local Cramer representative today or write us direct. The Cramer Controls Corporation, Box 7, Centerbrook, Connecticut. 6.11

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NEW TYPE 241 AUTOMATIC RESET INTERVAL TIMER, with full-scale repeat accuracy of ± 1/4 of 1%. Convenient pushbutton start, automatic and immediate reset for electrically operated equipment. Fully described in Bulletin PB-241.

NEW TYPE 412 TIME DELAY RELAY. Positive action ratchet clutch. Repeat accuracy of ± 1/4 of 1%. Introduces timed delay interval between operation of control circuit and load circuit. Ranges: 6 sec. to 24 hrs. Bulletin PB-311.

TYPE 690 TIME TOTALIZER has ± 0.01% accuracy. Totalizes in 1/100th increments to 60 sec. or 60 min. High-speed electromechanical clutching. An electrical stop clock for research or production. A-c or d-c models. Bulletin PB-610.

HIGH-TORQUE CRAMER MOTOR, truly synchronous; instant start, stop. 300 speeds, various output shafts available. Torque: 30 in.-oz. at 1 rpm. Permanently lubricated, mounts in any position, UL approved. Bulletin PB-110A.

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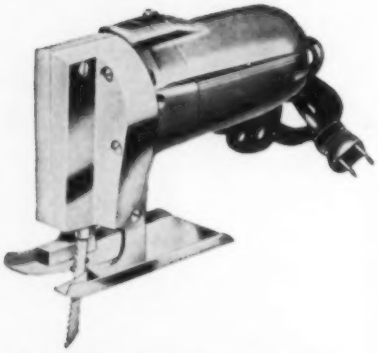


JOIN WITH HANDY & HARMAN SILVER BRAZING FOR PERMANENT PROFIT

Joint area is hand-fluxed with HANDY FLUX after which ½" piece of 1/16" EASY-FLO 45 wire is placed on top of joint area. Alloy cost is one half cent per joint.

Assemblies are placed between resistance-heating electrodes which serve also as a jig. Operator applies current with foot pedal. Melted EASY-FLO 45 penetrates joint area quickly and easily. Assemblies are then given rapid quench to preserve hardness of cross-slide and to remove HANDY FLUX easily. Time required for complete cycle: 22 seconds. This lady brazes from 1200 to 1500 assemblies per day.

GET THE FACTS OF EASY-FLO

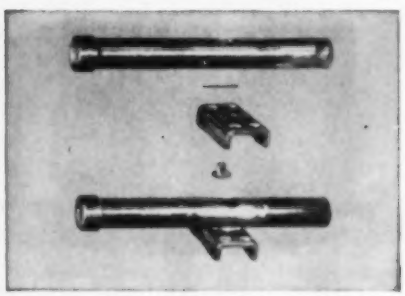
BULLETIN 20 tells you why high strength, speed and economy are inherent in EASY-FLO brazing. Also gives Handy information about joint design and fast brazing methods. We'll be pleased to send you a copy.

EASY-FLO 45 Solves Problems of Strain and Abuse

In this case, the strain and abuse are centered on the cross-slide joint of a bayonet power saw drive shaft. Made by Wen Products, Inc., Chicago, Illinois, for the do-it-yourselfer as well as the professional, this powerful tool operates at 2650 load strokes per minute and is expected to stand up to considerable strain and abuse throughout its lifetime.

The problem to be permanently solved was that of joining the steel cross-slide piece (.005 case hardened) to the drive shaft. The solution . . . silver brazing with EASY-FLO 45. A simple silver brazed joint assures all the strength this part will ever need. And the people at Wen Products were sure of it when they tested the part in this manner: After brazing, it was placed in a vise and the cross-slide piece was struck at right angles with a hammer. It was completely mangled before it was torn from the shaft. Thousands of these saws are in use today and there is no record of this joint *ever having failed* in service. That says a lot for silver alloy brazing . . . with EASY-FLO 45.

One of the beauties of silver alloy brazing is that it can join a wide variety of metals with the same excellent results and at remarkably low cost. Whatever you are making of metal, whether joints are involved *or not*, it will pay you to investigate EASY-FLO brazing. We will be glad to explain the benefits of simplified design made possible by modern silver brazing techniques —and how these advantages can be profitably applied to your production requirements. Just call us.



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Any peak transient voltages caused by fuse blowing are all well below the 1 minute withstand voltages of the circuit breakers.

Fuse replacement should be infrequent since relatively few high current faults occur. Most troubles are overloads or fault currents of low value. Time for fuse replacement is perhaps not of great importance since the blowing of the fuse indicates a fault of high current value and therefore serious trouble in the circuit.

Abstracted from "Coordination of Current Limiting Fuses and Low-Voltage Air Circuit Breakers," by M. S. Carlson and W. H. Edmunds, I-T-E Circuit Breaker Co., Philadelphia, Pa.; presented at Summer and Pacific General Meeting, San Francisco, Calif., of AIEE, Paper No. 56-773, June 25-29, 1956.

Discrete Compensation of Sampled-Data and Continuous Control Systems

A few examples on the application of the method have been presented which illustrate clearly the procedure steps outlined. Furthermore, methods of decreasing the sensitivity to shifts have been outlined and the effect of these shifts should not be overlooked.

A method of the physical implementation of the compensators is outlined which indicates the ease with which these compensators can be actually constructed.

The same procedure can be extended to include the compensation of systems with inherent delays in the forward or feedback paths which are not necessarily an integer value of the sampling period. Furthermore, as mentioned in Section III, an approximate method can be devised whereby continuous systems may be compensated with pure delays in the forward path of closed loop systems. The results of these two extensions will be published in a later paper.

The problems which have yet to be explored are a compromise between rise time and overshoot by cancelling only part of the poles, the effect of noise in the input, compensation of nonlinear systems, compensation by employing a variable pulse width, approximate realization of the compensator with continuous networks, and application of this method to the ef-

(Continued on page 341)

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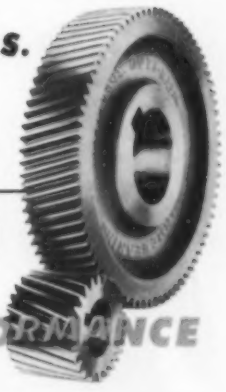
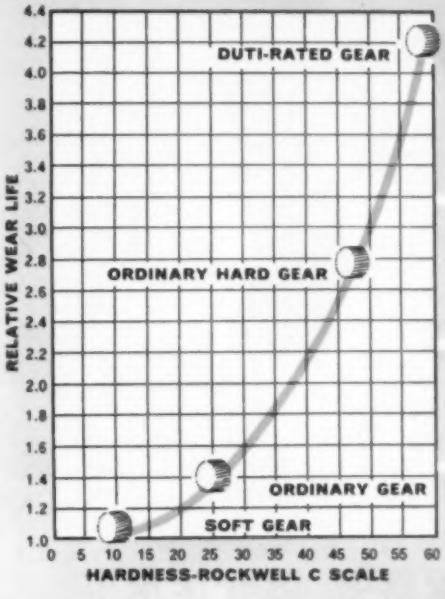


GEAR PERFORMANCE COMPARISON CHART



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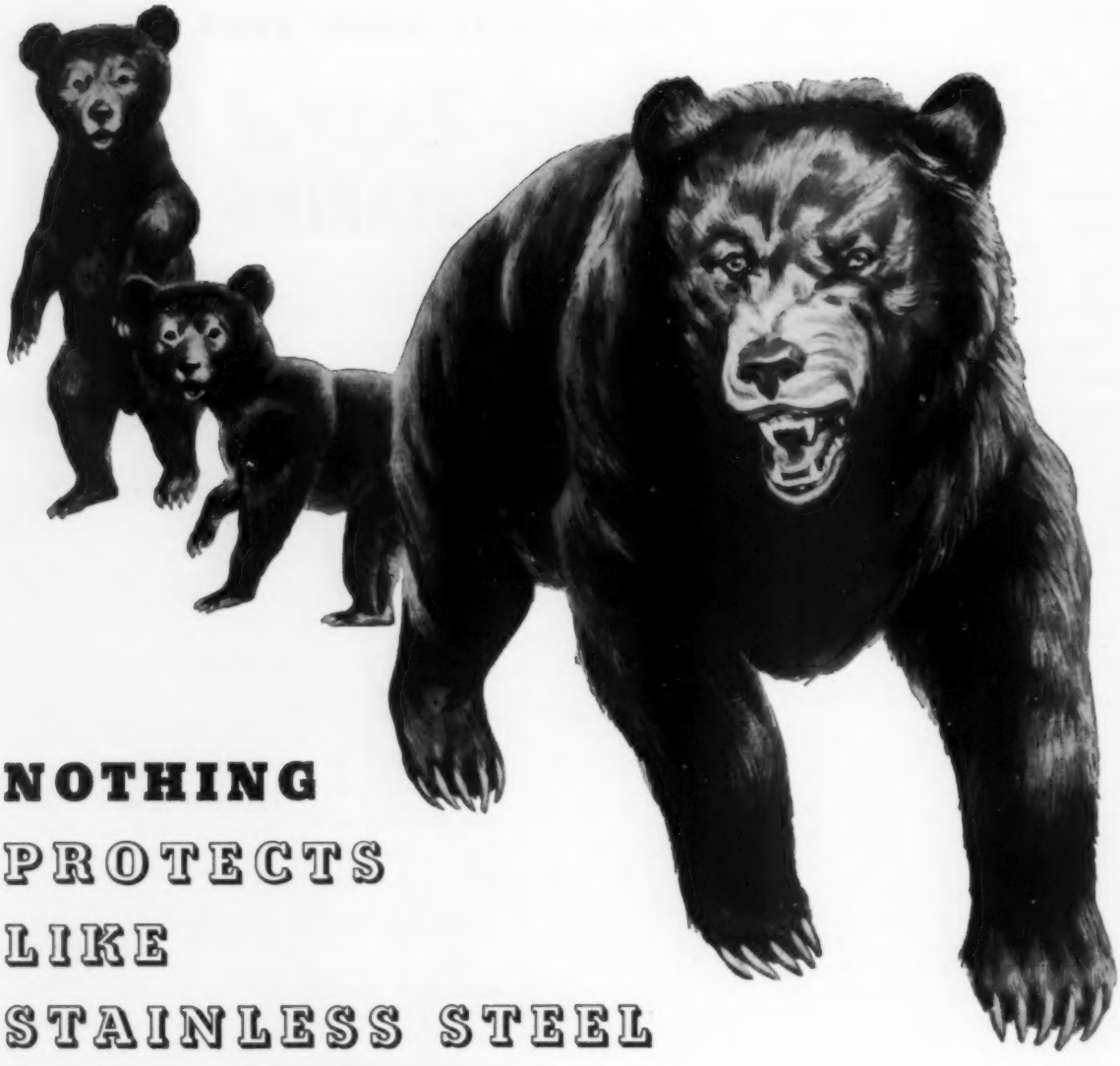

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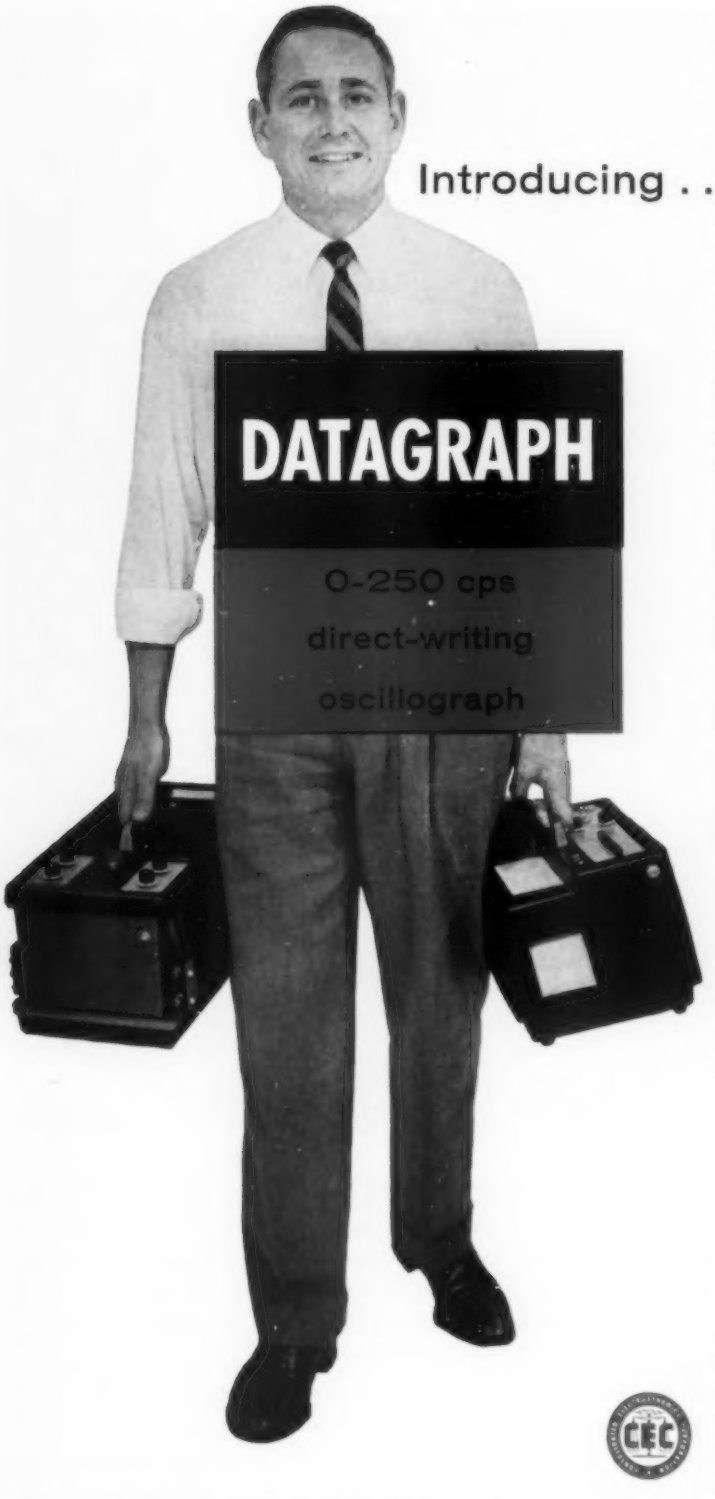

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WHAT ARE THE SYSTEM SPECIFICATIONS?

FREQUENCY RESPONSE....flat ±5% from 0 to 250 cps.

RECORD SPEEDS.....0.05, 0.2, 1, 5, 10 and 20"/sec.

NUMBER OF CHANNELS....2

RECORD SIZE.....70 mm x 500 ft.

AMPLIFIER INPUT IMPEDANCE .....100,000 ohms

SENSITIVITY .....1 inch per volt; 1 inch maximum peak-to-peak amplitude

DIMENSIONS AND WEIGHT:

Oscillograph .....9" x 10½" x 17¼", 60 lbs.

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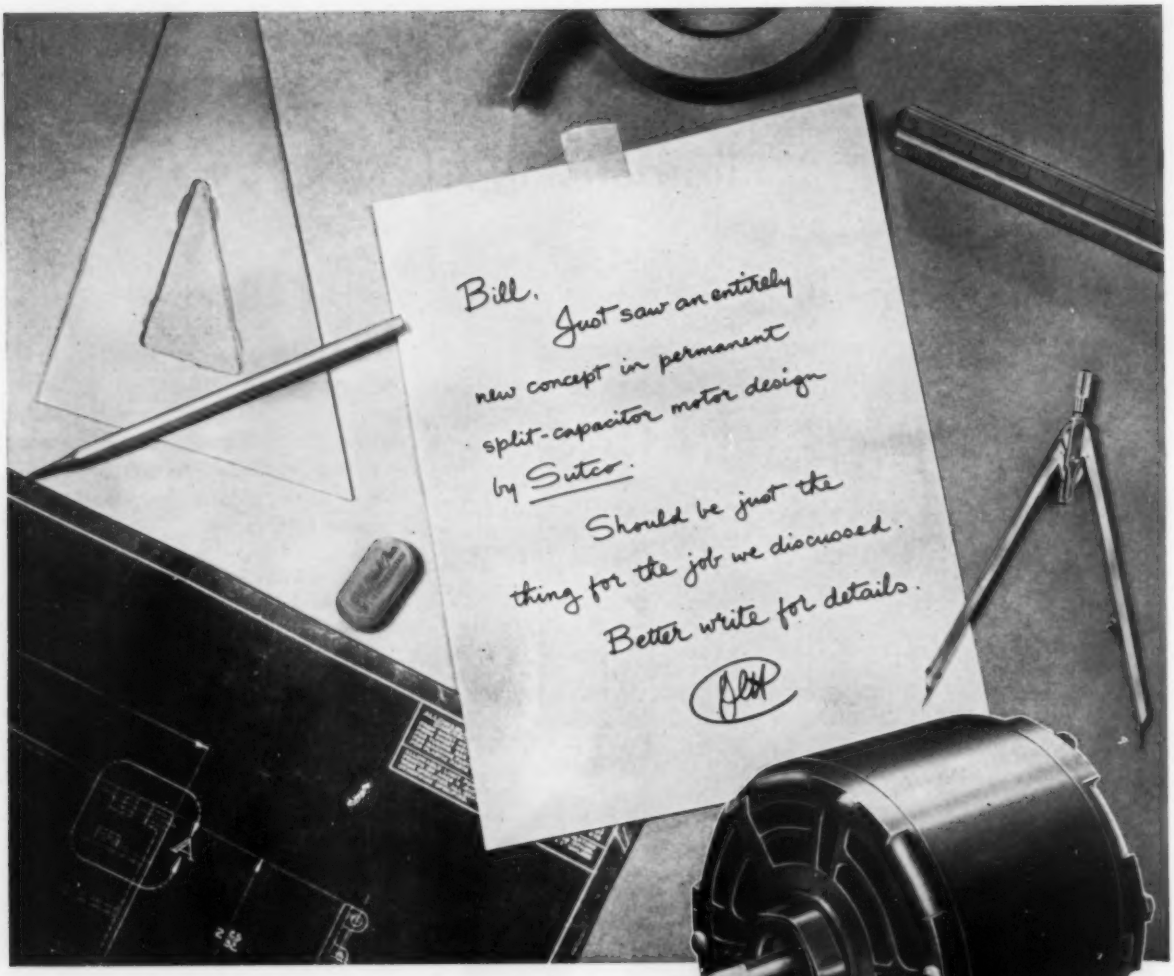
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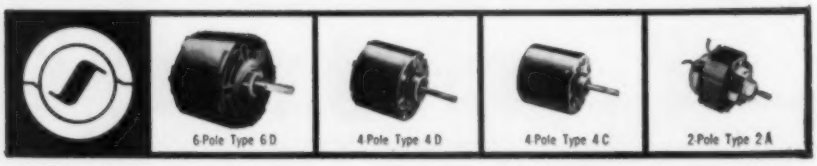


fective broadbanding of communication networks and systems without serious loss of gain.

Abstracted from "Discrete Compensation of Sampled-Data and Continuous Control Systems," by E. I. Jury and William Schroeder, University of California. Presented at AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25-29.

Static Strength of Aluminum-Alloy Specimens Containing Fatigue Cracks

Seven configurations of specimens made of 2024 and 7075 aluminum alloys in both rolled and extruded form were subjected to repeated axial loads until fatigue cracks of various lengths were formed. The specimens were then subjected to static tests to determine the residual static strength. Small cracks resulted in disproportionately large reductions of static strength, the reduction being greater for 7075 than for 2024 aluminum alloy.

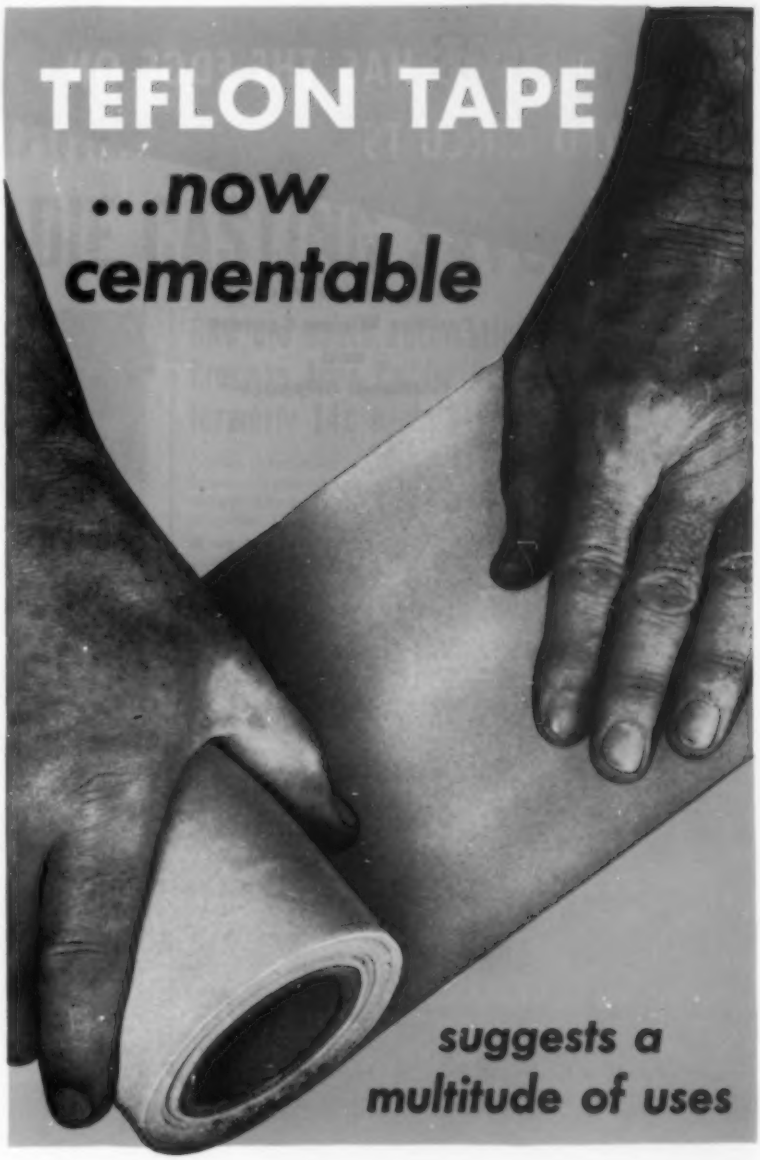
A simple method of analysis which predicts the observed results is developed and described. The method is based on calculation of an elastic stress concentration factor for the configuration and on corrections for size and plasticity according to the Neuber engineering factor and the Stowell formula, respectively. Empirical evaluation of the effective radius of curvature at the root of a fatigue crack in the materials tested and of the Neuber constant showed that good agreement was obtained when both quantities were assigned the value 0.0036 in.

One interesting aspect of the investigation was the appearance of the failure surfaces. In every case the boundary between the fatigue crack and the static failure was clearly visible. The contrast was particularly striking in the cases of ¾-in. thick specimens.

Herringbone patterns were found only in the 2024-T4 specimens with tangs.

Static failure of thick specimens without tangs in each of the materials was characterized by a granular surface on a plane normal to the axis of the specimen except for the outer ⅛ in. of material, where the familiar shear failure was present. Failures in 7075-T6 specimens with tangs were

(Continued on page 344)



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Cementable TEFLON Tape, 5 mil. to 60 mil. in thickness is available in continuous rolls up to 12 in. wide. Sheets are also available ½-in. thick in sizes to 24 x 24 in.; ½-in. thick in sizes to 48 x 48 in.

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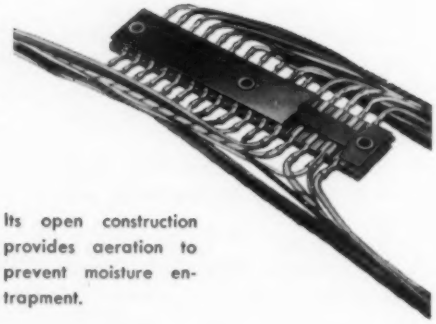
Another of the many unique designs made available by the AMP-Edge technique is the new, low-cost, compact AMP-Edge Connector Block. It allows freedom of arrangement, with small area displacement.



Its open construction provides aeration to prevent moisture entrapment.

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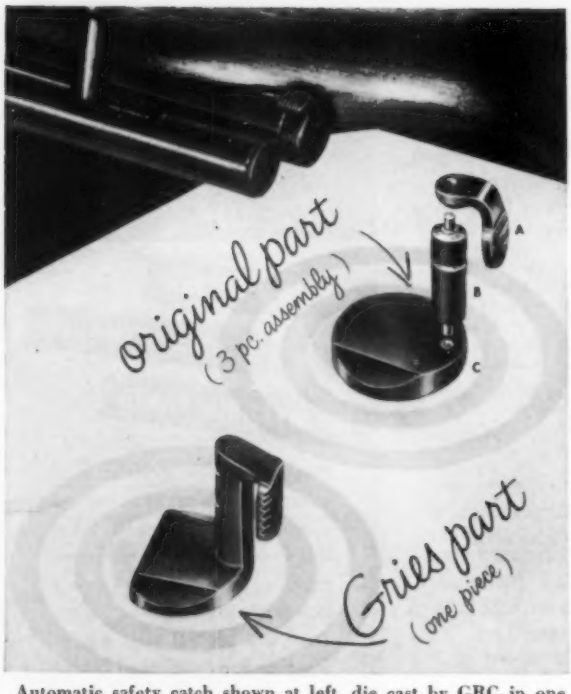

Automatic safety catch shown at left, die cast by GRC in one piece, replaces safety catch formerly assembled from 3 separate parts. Saving 12c per unit!

GRC die casts automatic safety catch for Crosman Arms Co. for less than 2c each—formerly 14c each. 1/7th of former costs!

The three-piece assembly of an automatic safety catch for the famous Crosman gas-powered rifle cost over 14c apiece. GRC's unique one-piece die casting techniques produce a functionally identical catch at a cost of considerably less than 2c apiece.

A saving of about 86%!

These Cost Sheet facts tell their own story:

Parts A, B & C plus assembly.....$143.00 per thousand
GRC 1-piece integral die casting....$ 16.50 per thousand

Saving $126.50 per thousand

This is just one example of the way Gries helps industry cut costs. By precision die casting of zinc alloy tiny parts in one piece—and in one automatic operation—substantial savings in time and money are realized. Designs can be simplified, reducing or completely eliminating machining and assembly operation. The die cast Crosman catch is not only lower in cost, but is actually a superior part; one-piece casting eliminates possible loosening of assembled parts and provides greater precision. Better appearance, too, resulted from GRC's die casting design flexibility.

Gries' techniques can make parts to the most precise specifications and mass-produce them in quantities of 100,000 to many millions. Smallness is unlimited (maximum weight ½ ounce, maximum length 1¾ in.) Widest scope of design is available.

An informative Die Castings Bulletin is available. Send for your copy.

Gries Makes Extensive Line of Die Cast Zinc Alloy Threaded Fasteners

Gries produces by their exclusive die casting technique a line of high quality, low cost threaded fasteners, including wing nuts, cap nuts, wing screws, round-head thumb nuts, round-head thumb screws, rivets, which are available in a wide range of sizes. Quick delivery from stock. Special to order. All are non-ferrous, rustproof with clean threads and bright finish. GRC mass production techniques provide lower costs. A new bulletin is now available. Write for your copy of Gries Industrial Fasteners Bulletin.

GRC "Intercast" Die Casting Offers Multiple-Parts Units with Movable Parts

In one automatic operation, Gries can "intercast" die cast tiny parts with movable elements, completely assembled, trimmed and ready to use. Elements fit precisely, yet move freely. Production of individual multiple-unit products or continuous "intercast" units is fast, economical and unique.

The "sister-hook", picture frame swivel rings, scissors, loose-leaf binder rings are 2-elements movable "intercast" parts, whereas the chain shown in the photo is an example of continuous "intercasting". Send for samples and full information.

GRC Diecast Gears and Pinions in One Piece at Lower Unit Costs

The exclusive Gries die casting of gears and pinions in one operation produces one-piece assemblies faster at less cost. Cast with shafts or center holes or in combination with cams, hubs, etc., permitting wide design flexibility. Many combinations from stock dies available at no tool cost. Write for full information, samples.

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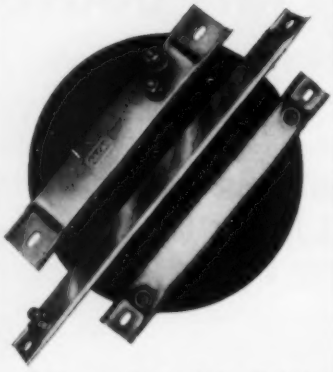

1. **When application is for:** Contact heating of dies, platens, molds, or any items with flat surfaces to which elements may be clamped. Also air heating source for ovens, air ducts, dryers.
2. **When specifications call for:** Seamless one-piece sheath; rugged non-oxidizing terminal posts; steel sheath for sheath temperatures to 750°F; Chromalloy sheath for sheath temperatures to 1200°F; 8" to 42½" lengths (or longer); 150 to 1500 watts (or higher).
3. **When you have "hot" problems:** Vulcan Engineers are ready to supply special heating units — engineered to your needs.

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Constructed basically like the strip heaters, Vulcan Electric Band Heaters are designed for clamping around tanks, pipes, injection heads, etc. Standard width is 1½"; inside diameters from 6" to 15" (special smaller or larger sizes available). Semi or full circular bands. Equipped with mounting tabs or clamping bands.

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ELECTRIC COMPANY
DANVERS 18, MASS.

Cartridge • Strip • Tubular • Immersion Electric Heaters • Soldering and Branding Irons Solder and Glue Pots

extremely jagged and had little tendency to occur along a plane normal to the axis of the specimen. Some evidence of lamination in the material was found for these latter specimens although specimens without tangs cut from the same bars showed no such characteristics.

Fatigue cracks in the sheet specimens and thin extrusions were usually in a plane normal to the surface. The statically failed portion of the surface was usually of the shear type. However, in 7075-T6 specimens there was a consistent tendency for material near the middle of the thickness to fail along a surface normal to the face of the sheet. The usual shear failure was present near both faces.

Abstracted from "Static Strength of Aluminum-Alloy Specimens Containing Fatigue Cracks," by Arthur J. McEvily, Jr., Walter Illg, and Herbert F. Hardrath, Langley Aeronautical Laboratory, Langley Field, Va., NACA Technical Note 3816, Oct. 1956.

Selenium Rectifiers and Their Aging Characteristics

Selenium rectifier equipment, properly designed, installed and maintained, will give many years of satisfactory and reliable performance. A large quantity of rectifiers designed at 2.0 times normal rating or better have been operating for 5 or 6 years without stack failures, 5, 6, and 7 days a week, 24 hr a day. This is equivalent to 15 or 18 years with 8 hr shift.

The importance of total selenium area for better life characteristics has been indicated in this paper.

During the past year there has been a great deal of progress made with selenium rectifiers in reducing their aging characteristics with the development of high temperature cells and special high density cells. It is believed that the barrier layer in the selenium cells is one of the contributing factors in the aging of the cells. A study is now being conducted on these high temperature and high current density cells. This will have to be a subject of another analysis, and it will be another year or two before conclusive results can be obtained.

Abstracted from "Selenium Rectifiers and their Aging Characteristics," by C. E. Brigham, Vice President, Richardson-Allen Corp. Presented at AIEE Fall General Meeting, Oct. 1-5, Chicago, Ill.

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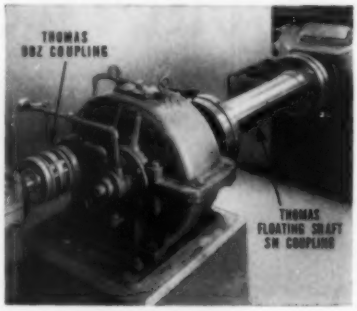

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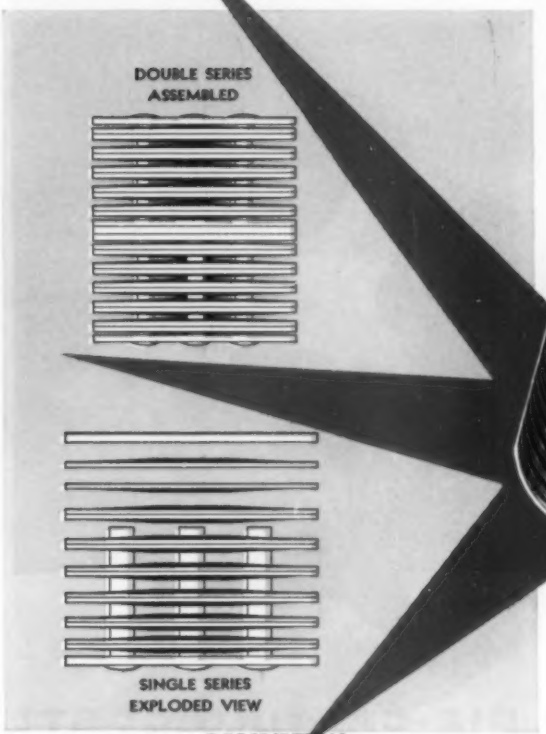
Energy* Cartridge

for high loads at minimum deflection



DESCRIPTION

This new cartridge* provides a compact stack of pre-assembled Belleville washers, a solid, one-piece unit—easier to handle and install than loose washers. The washers are held together with face plates and pins or rivets at or near the neutral axis. Washers may be assembled in series, parallel, and parallel-series according to space and load requirement. Eliminates manual hazard of assembling in wrong sequence at assembly point.

APPLICATIONS

Used as a shock-absorber and in vibration-isolation mountings; in die springs, automotive drives, machine-tool chuck and spindle drives, etc.; to exert constant pressure in cases of expansion due to temperature variations; fills need for a spring with constant load-deflection characteristics acting in compression.

For further information or specific application, consult engineers at any Division. Write for booklet — "Belleville Springs and Energy Cartridge."

*Reg. U.S. Pat. Off.

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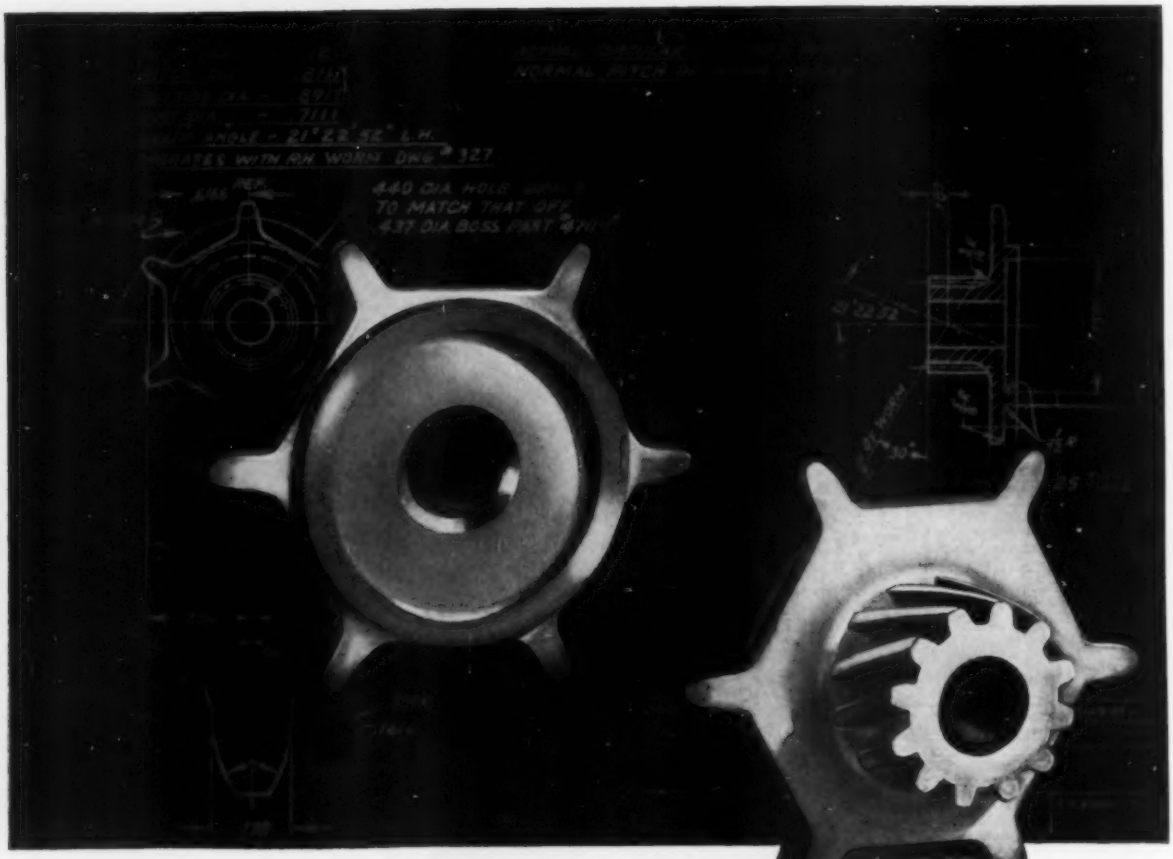

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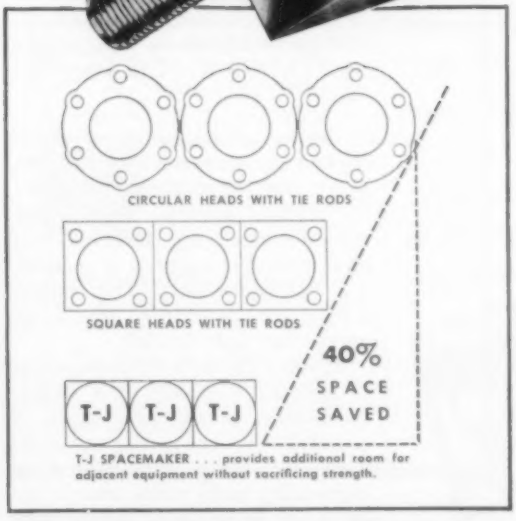
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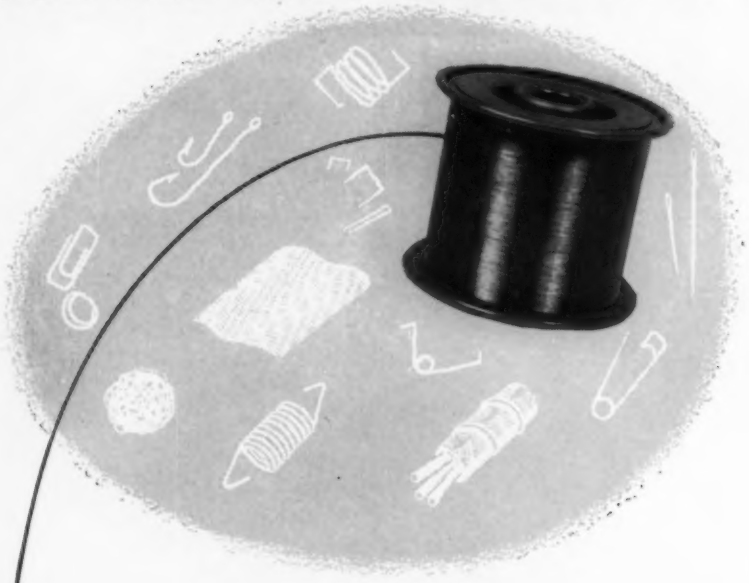

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NEW BOOKS

Analysis of 1956 National Electrical Code

Compiled by H. P. MICHENER, *NEMA Engineering and Safety Regulation Dept. 4¾ x 7 in., 45 pp, paperbound. Published by National Electrical Manufacturers Assn., 155 E. 44 St., New York 17, N. Y. $0.25.*

This book describes changes which have occurred in the code since the 1953 edition. Where the reason for the revision may not be obvious, a brief explanation is given.

There have been a number of recent changes of importance, including new tables for aluminum conductors, revised running currents for d-c motors to 3 hp and for single-phase motors to 1½ hp, new definitions of service entrance conductors, recognition of new 90 C rubber-covered wire and, further, extension grounding type receptacles for portable equipment.

Engineering Analysis

STEPHEN H. CRANDALL, *Massachusetts Institute of Technology, 9¼ x 6 in., 417 pp. Published by McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y. $9.50.*

This book deals with the analysis of engineering problems of great complexity and the methods for organizing practical programs for their numerical solution, and, therefore, is of great interest to engineers or engineering mathematicians. The mathematical level is that of second-year engineering graduate work.

A special feature is the arrangement of material according to a natural classification of the basic types of problems in engineering analysis. Three items frequently omitted in engineering mathematics courses are developed in the text: matrix notation, the calculus of variations, and the theory of characteristics of partial differential equations.

Three broad classifications of problems are recognized: equilibrium,

(Continued on page 350)

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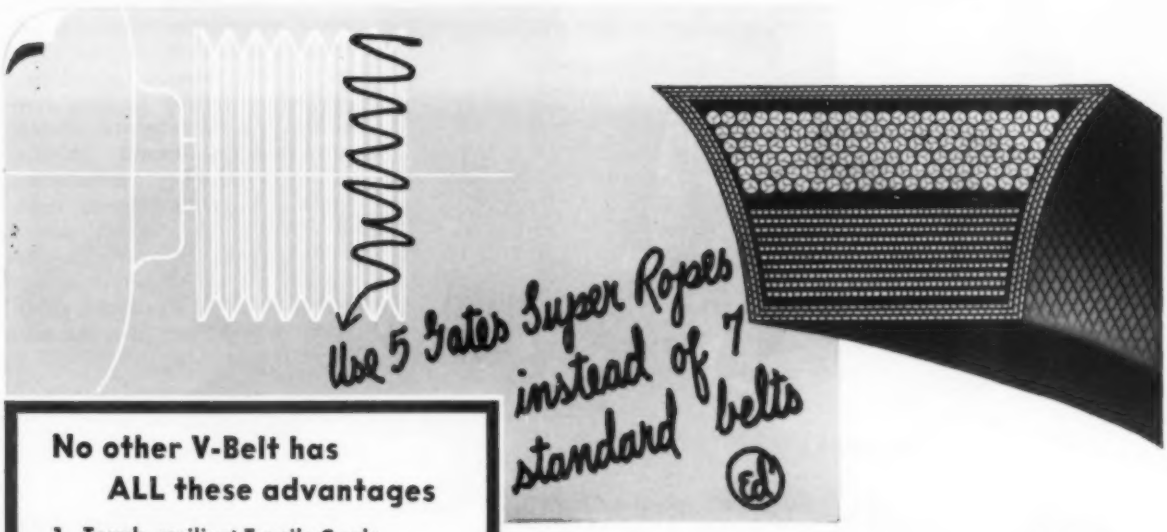

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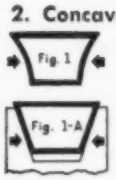

Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . far longer belt life.

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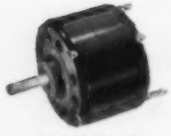
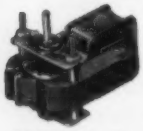


MODEL B

4-pole, 4-coil shaded pole AC Induction Type

MODEL A

2-pole, shaded pole AC Induction Type



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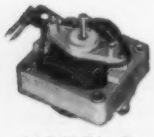

MODEL E

4-pole, shaded pole AC Induction Type

MODEL D

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MODEL O

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Procedures suitable for hand computation and for automatic machine computation are treated, including iteration, relaxation, perturbation, variational and finite difference methods. There are 432 exercises, most of which represent alternative developments, modifications, or extensions of the test. Some drill problems are included. Answers are given for most of the exercises.

Foreign Scientific and Technical Meetings

Paper-bound, 10¼ x 8 in., 48 pp. Available from Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C., single copies, $0.20 domestic, $0.25 foreign.

This quarterly list of forthcoming international and foreign scientific and technical meetings supersedes all earlier lists issued. The meetings listed have been selected because of their possible interest to American scientists and include all those definitely or tentatively scheduled from Oct. 1 1956 through 1959.

Effect of Vacuum Degassing On Aluminum Alloys

PB121325, E. E. Layne and H. F. Bishop, Metallurgy Div., Naval Research Laboratory. Available from U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C. $0.50.

It has been demonstrated that gas porosity can be eliminated from nonferrous castings by holding the melt in a vacuum chamber for a period of 5 to 10 minutes prior to pouring. This procedure does not require the expensive equipment generally associated with vacuum melting; a mechanical pump is sufficient to bring the pressure within the chamber

(Continued on page 354)

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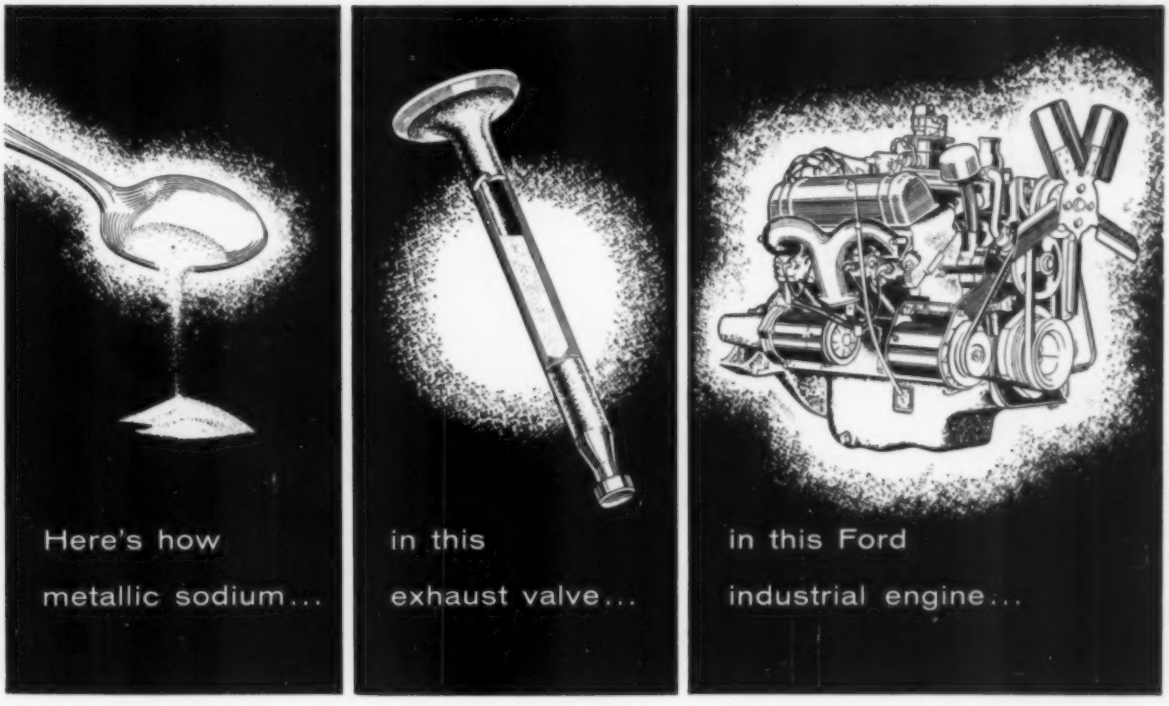

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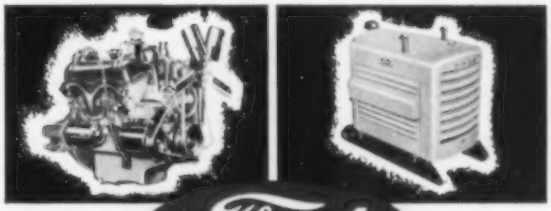

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Either coating provides corrosion resistance superior even to complicated electrolytic treatments in a fraction of the time. These coatings also offer many other valuable characteristics: they have low electrical resistance, they aid in arc-welding, provide a good base for bonding compounds, have no effect on the dimensional stability of close-tolerance parts. Final appearances ranging from clear through yellow iridescence to full brown can be obtained. By dyeing, you can produce red, green, blue, orange or yellow finishes.

IRIDITE # 15 for MAGNESIUM

Produces a protective, paint base film with corrosion resistance at least equal to that obtained from long, high-temperature dichromate treatments in a fraction of the time and at room temperature. The appearance of the coating can be varied from light brown to dark brown and black.

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down to the 0.2 to 0.4 mm range required. The vacuum degassing process does not require major modifications in foundry procedures since it involves less time than is often required for conventional inert gas flushing procedures for removing hydrogen.

This study shows that while mechanical properties are improved by the presence of grain refining additions and by rapid solidification such as occurs in thin sections and chill molds, further improvements in tensile strengths, yield strengths and elongations are effected by the vacuum degassing treatment.

Manual On Electrical Insulations

8½ x 11in., 300 pp. *Published by Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.* $5.

This book seeks to describe and evaluate all of the commonly used insulations for electrical and electronic equipment. It is tab-indexed for convenience in locating the sixteen different chapters, each devoted to different types of electrical insulation materials. Original illustrations, drawings, specification tables and graphs are used. A complete alphabetical index and a guide to official standards for electrical insulation materials are also provided.

Electronic Components Symposium

Sponsored by American Institute of Electrical Engineers, Institute of Radio Engineers, Radio-Electronics-Television Manufacturers Assn. and West Coast Electronic Mfr. Assn., 8½ x 11 in., 240 pp. *Published by Engineering Publishers, GPO Box 1151, New York 1, N. Y.* $8.25.

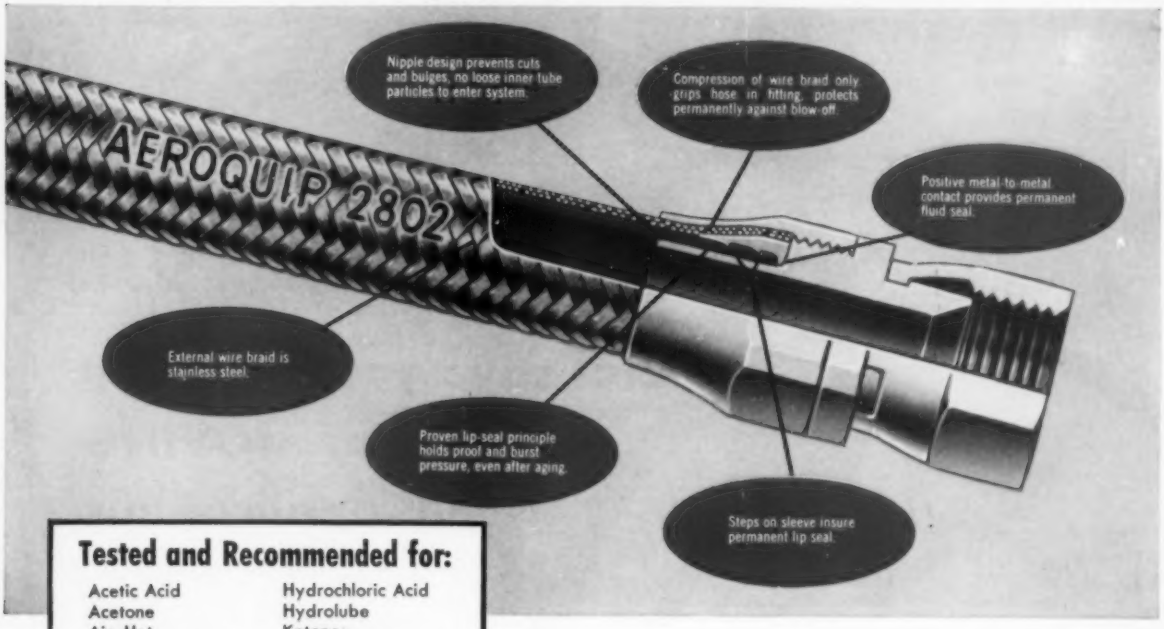
The marked recent advance in electronic systems has been accompanied by continuing advances in components.

The proceedings of the 1956 symposium has 43 papers covering a wide variety of new subjects such as materials progress, electronic tubes, solid-state devices, passive components, and they include treatment of reliability,

(Continued on page 358)

Aeroquip Announces 2802 Teflon* Hose with Reusable "*super gem*" Fittings

NOW YOU CAN ASSEMBLE TEFLON HOSE AND LEAKPROOF FITTINGS BY HAND!


AEROQUIP 2802
Nipple design prevents cuts and bulges, no loose inner tube particles to enter system.
Compression of wire braid only grips hose in fitting, protects permanently against blow-off.
Positive metal-to-metal contact provides permanent fluid seal.
External wire braid is stainless steel.
Proven lip-seal principle holds proof and burst pressure, even after aging.
Steps on sleeve insure permanent lip seal.

Tested and Recommended for:

Acetic Acid	Hydrochloric Acid
Acetone	Hydrolube
Air, Hot	Ketones
Alcohols, Aliphatic	Lacquers, Solvents
Ammonia, Aqueous	Lindol, Cellulube
Aqua Regia	Lube Oil, Hot
Asphalt	Mercury
Benzene (Benzol)	Naphtha
Carbolic Acid, Hot	Naphthalene
Chlorinated Solvents	Nitric Acid
Chlorine (wet or sol.)	Pydraul F-9
Creosote Oil	Steam
Ethers	Sulphur Dioxide
Furfural	Sulphuric Acid
Gasoline, Sour or Ref.	Trichlorethylene, Touluene (Toluol)
Hydraulic Oil	Water, Fresh or Salt (hot or cold)
Hydrobromic Acid	

For temperatures from —65° F. to +450° F. Operation beyond these limits subject to Aeroquip approval.

New Aeroquip 2802 Industrial Teflon Hose and Reusable "*super gem*" Fittings make possible wide use of Teflon hose lines for fluid systems subject to extreme temperatures and corrosive fluids. No expensive swaging machines are required. To make Teflon hose lines, just attach the "*super gem*" Fittings to Aeroquip 2802 Hose using ordinary hand tools. It takes only minutes to assemble a factory-quality Teflon hose line right in your plant. "*super gem*" Fittings are economical because they can be detached and used again and again.

For full technical information on Aeroquip Teflon Hose and Reusable "*super gem*" Fittings, write for Bulletin IEB-26. See our catalog pages in Sweet's Product Design File, Section 6d.

"*super gem*" is an Aeroquip Trademark. *DuPont trade name for its Tetrafluoroethylene resin.

Aeroquip

REG. TRADEMARK

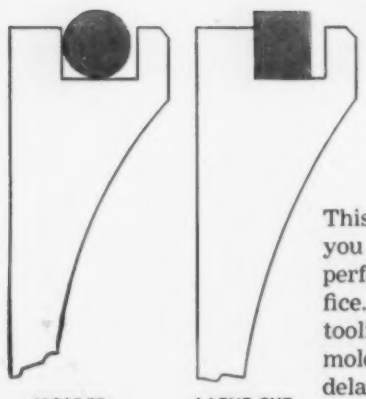
AEROQUIP CORPORATION, JACKSON, MICHIGAN

IN CANADA: AEROQUIP (CANADA) LTD., TORONTO 10, ONTARIO

LOCAL REPRESENTATIVES IN PRINCIPAL CITIES IN U.S.A. AND ABROAD • AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Why ACADIA LATHE-CUT SYNTHETIC RUBBER SEALS

can save you money in *STATIC* or *MOVING* seal applications



MOLDED O-RING SEAL

LATHE-CUT SEAL

This seal will save you money with no performance sacrifice. Minimum tooling cost, no molds, no costly delays. Can be made up to 25" I.D.

Acadia Synthetic Rubber Parts are of the highest quality components, processed for oil resistance, good aging properties, resistance to heat. They can be furnished in any dimension or special compound you desire to precision tolerances. They are another example of Acadia's ability to SAVE YOU MORE..SERVE YOU BETTER.

There's an Acadia Sales engineer near you to serve you. Write us today, and we'll put him in touch with you immediately.

ACADIA *Synthetic* **PRODUCTS**

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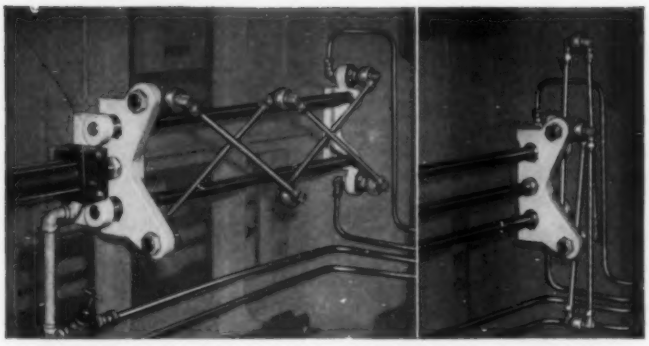
MANUFACTURERS AND CUTTERS OF WOOL FELT



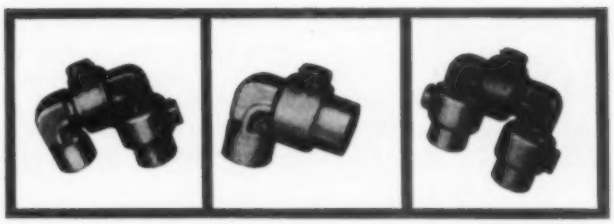
Chiksan Swivel joints, with full 360° rotation allow duplicate sets of lines (left) to be compacted into small spaces (right).

PROBLEM: EXTREME BEND RADII

SOLUTION: **CHIKSAN SWIVEL JOINTS**

Got a bend radii problem? Then let Chiksan engineers go to work on the answer. Chiksan has the years of experience and know-how to handle your problem quickly, efficiently.

Chiksan Swivel Joints provide unlimited flexibility in a compact package to meet your exacting pressure and temperature requirements. Be it for air, hydraulics, fuel, oil, water or other fluids, it will pay you to have Chiksan provide the right swivel joint for *your* bend radii problem.



Typical Chiksan Swivel Joints

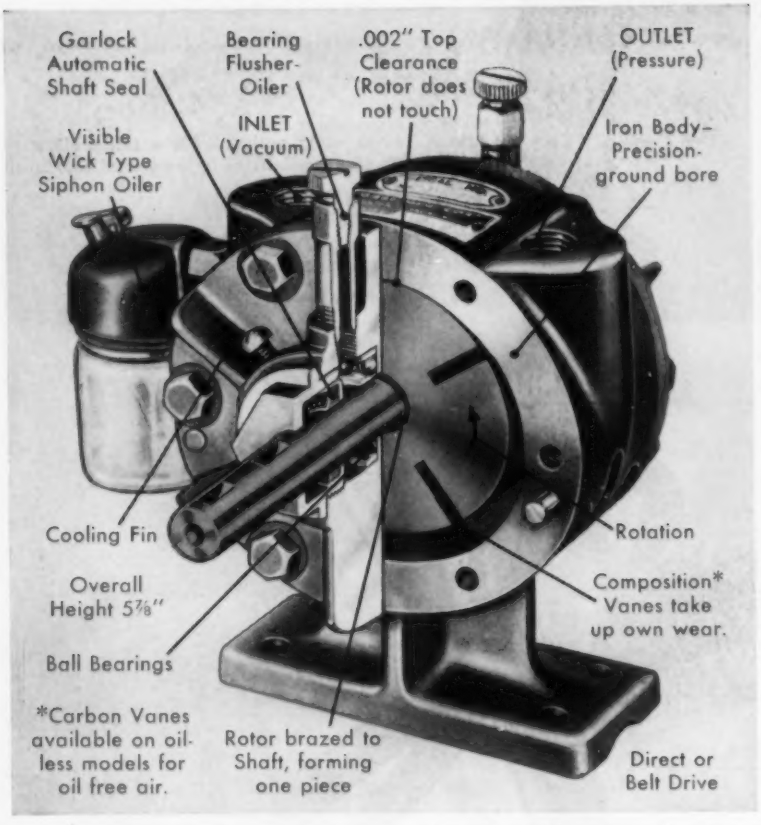
FOR FREE CATALOG WRITE DEPT. 202.

CHIKSAN

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION fmc

CHIKSAN COMPANY — BREA, CALIFORNIA • CHICAGO 3, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Chiksan of Canada, Ltd., Edmonton, Alta


Garlock Automatic Shaft Seal
Bearing Flusher-Oiler
.002" Top Clearance (Rotor does not touch)
OUTLET (Pressure)
Visible Wick Type Siphon Oiler
INLET (Vacuum)
Iron Body–Precision-ground bore
Cooling Fin
Rotation
Overall Height 5⅞"
Composition* Vanes take up own wear.
Ball Bearings
*Carbon Vanes available on oil-less models for oil free air.
Rotor brazed to Shaft, forming one piece
Direct or Belt Drive

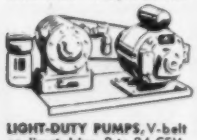
rotary vane

Quality and simplicity keep

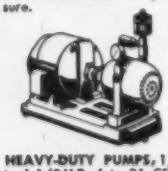
GAST AIR PUMPS

operating for years at high efficiency levels

INTEGRAL-MOTOR PUMPS 1/12 to 1/3 H.P. .6 to 4 CFM. to 28" VAC., to 25 PSI.



LIGHT-DUTY PUMPS, V-belt or direct drive. 2 to 24 CFM. Moderate vacuum or pressure.



HEAVY-DUTY PUMPS, 1/4 to 1-1/2 H.P. 4 to 21 CFM. To 28" VAC. or 30 PSI. Cooling fans and fins.

As original components—or for special plant use—Gast Air Pumps offer important advantages. This cutaway reveals many reasons why they are specified as "original equipment" by more and more leading manufacturers.

All models are built to high quality-precision standards in a new, modern plant. All embody this inherently efficient, simple rotary-vane design. Balanced rotor is free of vibration. Sliding vanes are light in weight—for minimum motion-energy-friction loss compared to other pump designs. As vanes take up their own wear automatically, pump delivers full performance through years of use.

Get full details—write for "*Application Ideas*" *Booklet and Catalog.* Many sizes—*mention capacity and type that interests you!* **Gast Manufacturing Corp.,** P. O. Box 117-V, Benton Harbor, Michigan.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- **AIR MOTORS** TO 4 H.P.
- **COMPRESSORS** TO 30 P.S.I.
- **VACUUM PUMPS** TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

theory and applications, instrumentation and measurements.

The book contains information about new types of components, and improvements in conventional components such as "Effects of Nuclear Radiation on Electronic Components," and "Ceramic Transformers and Filters."

Applied Electrical Measurements

ISAAC F. KINNARD *with* 14 *contributors.* 6¼ x 9¼ *in.,* 600 *pp. Published by John Wiley & Sons, Inc.,* 440 *Fourth Ave., New York* 16, *N. Y.* $15.

This book might have been more properly titled, "Theory of Operation of Electrical Measuring Instruments," since specific application information included is negligible. The book does, however, go into broad detail as to how various electrical instruments and measuring systems operate, including the mathematics describing instrument and system operation. Electrical measurements of standard electrical quantities such as current, voltage, resistance, inductance, capacitance, power, magnetic fields, waveforms, frequency, and others are included. In addition, measurement of nonelectrical quantities such as light, heat, sound, liquids and gases, statics and kinetics, and time fill a large portion of the text.

The book is valuable, however, because it brings together much information previously available only in separate references. Also, each chapter has a detailed bibliography from which the reader may obtain further extensive information on material described in that chapter.

Mechanical Design for Electronics Production

JOHN M. CARROLL, *Assoc. Editor, Electronics.* 6¼ x 9¼ *in.,* 348 *pp. Published by McGraw-Hill Book Co., Inc.,* 330 *W.* 42 *St., New York* 36, *N. Y.* $6.50.

This book is based on a series of articles in *Electronics* which presented information needed by electrical, mechanical, manufacturing, and electronic engineers and has a great deal

(Continued on page 362)

RESULT: Better Finish at Lower Cost

In addition to the long recognized advantages of Eaton Permanent Mold Gray Iron Castings, the use of shell coring gives an even greater uniformity of structure and an improvement in internal surface finish. This results in machining economy and fewer rejections, which, in the end, mean lower cost of finished parts.

If you have applications where more than ordinary quality is required, Eaton Permanent Mold Gray Iron Castings offer many advantages. Whatever your requirements, our engineers will be happy to work with you.

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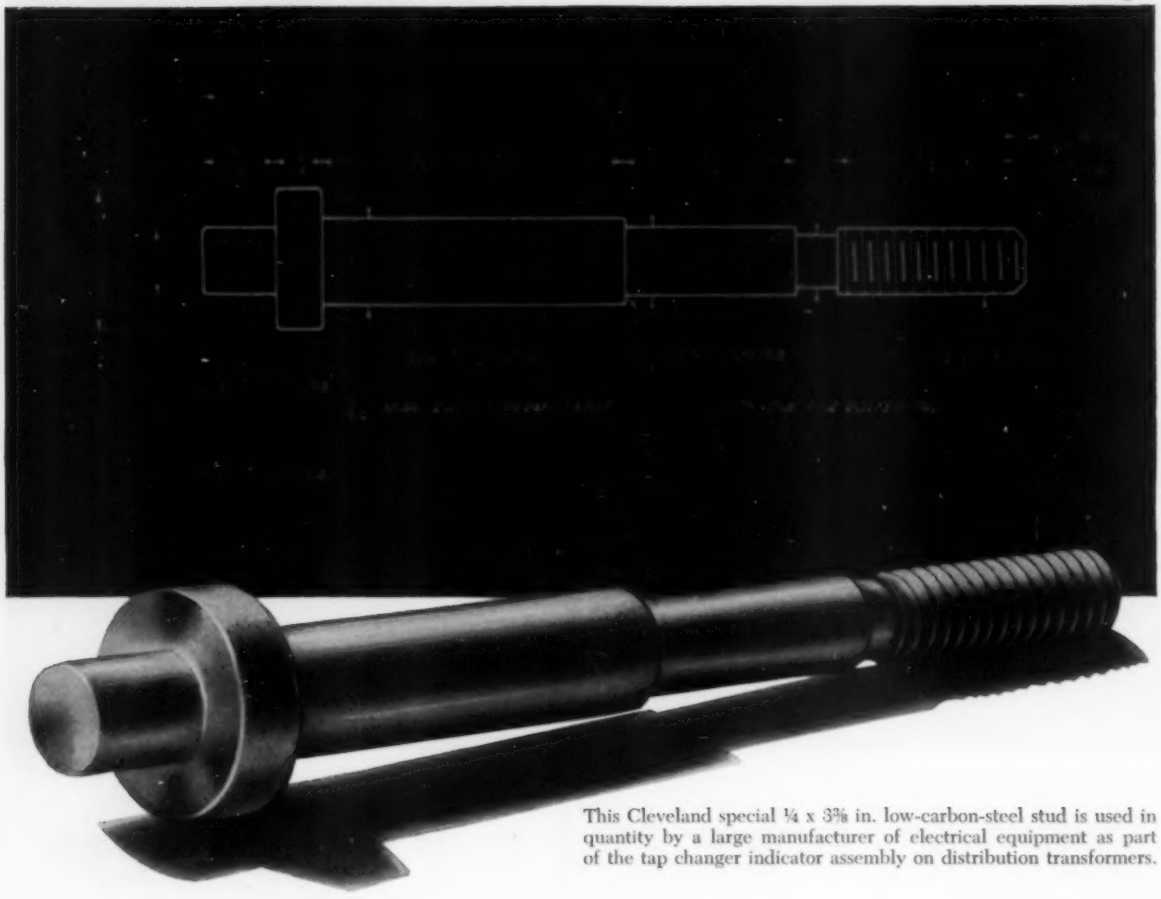
Consider these Important Advantages

- ★ Intricately cored sections
- ★ Uniformity of castings
- ★ Higher machining feeds and speeds
- ★ Substantially increased tool life
- ★ Dense, non-porous, homogeneous structure
- ★ Freedom from inclusions
- ★ Excellent tensile strength
- ★ Ability to take high surface finishes
- ★ Freedom from leakage under pressure

EATON

FOUNDRY DIVISION
MANUFACTURING COMPANY
VASSAR, MICHIGAN

CLEVELAND SPECIAL HEADED AND THREADED PRODUCTS



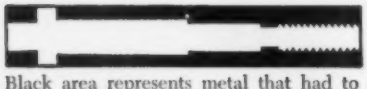
This Cleveland special ¼ x 3⅜ in. low-carbon-steel stud is used in quantity by a large manufacturer of electrical equipment as part of the tap changer indicator assembly on distribution transformers.

Cost of special collar stud is cut 20% by Cleveland's cold forming techniques

The famous Kaufman Double Extrusion Process which turns out millions of Cleveland precision cap screws yearly is highly adaptable to low-cost production of your fastener-type specials.

The tap changer stud pictured above is typical. Used by a well-known electrical equipment manufacturer, it was previously cut from bar stock. The special head, double shoulders, and groove above the threads meant numerous machining operations and considerable scrap.

♦ ♦ ♦



Black area represents metal that had to be cut away when stud was produced by machining. In the Cleveland cold forming process almost all the metal in the working slug is present in the finished part. The customer saves the difference.

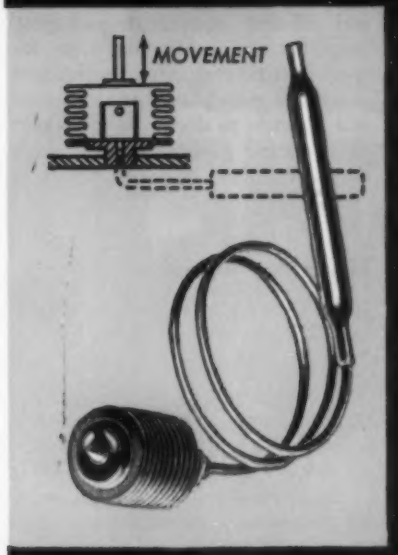
Cleveland now cold forms this special stud at 20% less cost to the customer, while holding the specified .005 in. tolerance. And the part is stronger. In the head, threads and fillets, grain flow is symmetrical and unbroken. In addition, the forging action of the Kaufman process toughens surface metal while leaving the core ductile. Both fatigue resistance and tensile strength are thus increased.

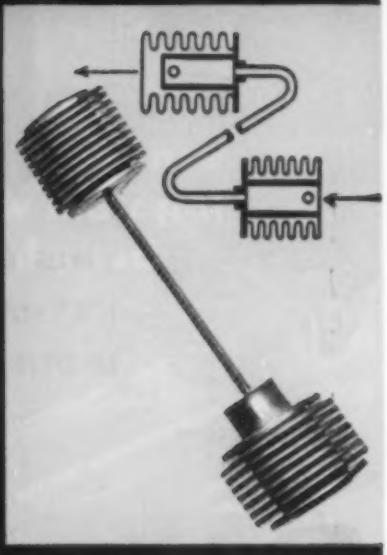
We are regularly cold forming close-tolerance specials—many with unusual or extreme upsets—in large quantities. So whether your part is simple or complex, it will pay you to check with Cleveland, particularly at the design stage. There is an excellent chance that through cold forming we can cut the cost and improve the physical properties of the part you have in mind.

Write for a copy of our folder "Specials by Specialists"

THE CLEVELAND CAP SCREW COMPANY
4444-4 Lee Road, Cleveland 28, Ohio

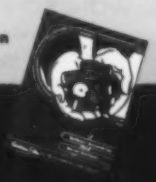
TO CONVERT OR ABSORB THERMAL EFFECTS AT LOW COST SYLPHON BELLOWS AND ASSEMBLIES





Whether design problems involve thermal, pressure or mechanical effects, Fulton Sylphon can help you use the simple, foolproof bellows principle to best advantage. For one thing, an unmatched engineering service assures you of the *right* bellows or bellows assembly. Specialized skills and facilities also enable Fulton Sylphon to produce complete bellows assemblies at lower cost than you could yourself. And only from Fulton Sylphon can you get the extra know-how that comes from 52 years of experience with every conceivable bellows application!

Send for Bellows Bulletin CP-1400



FULTON SYLPHON

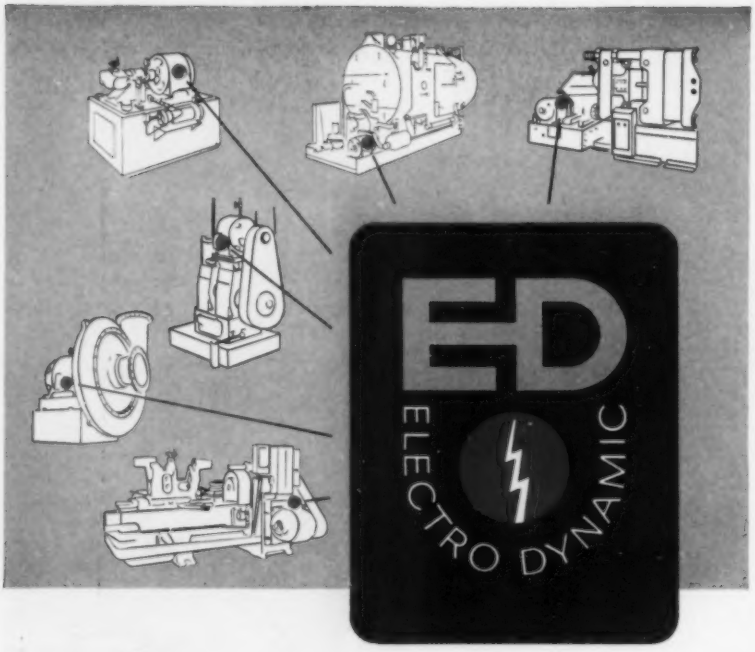
BELLOWS HEADQUARTERS, U.S.A.

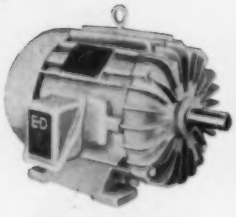
Robertshaw-Fulton

CONTROLS COMPANY

Mr. Controls

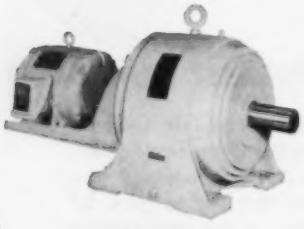
FULTON SYLPHON DIVISION · Knoxville 1, Tenn.





STANDARD MOTORS

THIS EMBLEM IDENTIFIES EXTRA DEPENDABLE INDUSTRIAL MACHINERY



GEAR-ED-MOTORS

The red *power spot* on industrial machinery means "Powered by Electro Dynamic." Such machinery relies with confidence on the *extra dependability* of Electro Dynamic motors, the proven industrial motors which give industrial equipment *extra dependable* operation.

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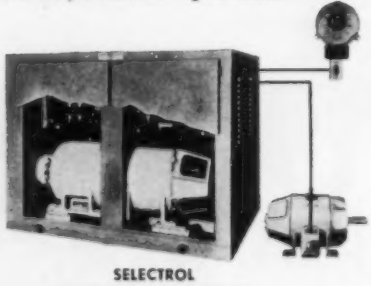

SELECTROL VARIABLE-SPEED DRIVES

ELECTRO DYNAMIC
DIVISION OF GENERAL DYNAMICS CORPORATION
BAYONNE, NEW JERSEY

of information concerning the design and manufacture of devices using electron tubes and transistors.

Included are: processes and materials, mechanical layout of equipment, sheet-metal work, machining operations, electric and magnetic shielding, use of resins and other sealing compounds, mechanisms and electric motors, nonelectrical acceptance tests required for government equipment, and the application of human engineering factors to control panel design.

Other subjects included are: mechanized assembly, modular design and efficient equipment packaging, properties and application notes for special plastic compounds, techniques of etched wiring and dip soldering, and advances in design of equipment to withstand vibration, shock, high temperatures and humidity.

Hydraulics Refresher

JOHN D. CONSTANCE, *P. E. Paperbound. 11 x 8½ in., approx. 100 pp. Published by De Troy Press, Inc., Englewood, N. J. $3.*

This is a new, second edition of a home study aid for candidates for professional engineering licenses. It is recommended for use in preparing for examinations for professional engineer, civil service engineering grades, power engineer. Present edition includes sections on hydrodynamics, circular orifices, sharp-crested weirs, flow of liquids through pipes, water flow in open channels, centrifugal pumps.

Application of Spring Strips to Instrument Design

9½ x 6 in., 25 pp. Notes on Applied Science No. 15, Dept. of Scientific Industrial Research, National Physical Laboratory. Published by Her Majesty's Stationery Office, York House Kingsway, London W.C. 2, England. About $0.36.

Spring strips of tempered steel or other elastic materials have many uses in the design of all types of measuring instruments. These uses include flexible couplings and pivots, the mag-

(Continued on page 364)

Cincinnati, Ohio, May 6-10, 1957

AFS THE 1ST ENGINEERED CASTINGS SHOW

ATTEND and compare thousands of Castings in every known metal and alloy . . . Steel, Aluminum, Gray Iron, Zinc-base, Titanium, Malleable Iron, Brass and Bronze, Ductile Iron, Magnesium, Beryllium, etc.

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HEAR papers on design, metals, materials, properties, specifications, applications . . . *authentic* engineering data, written for *Engineers* by Castings authorities.

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ATTEND the 1st ENGINEERED CASTINGS SHOW *see for yourself* why a Casting is the most versatile engineering material known . . . as a component or end product . . . in every industry and field of manufacture.

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Complete Catalog File!

Complete bound file with ordering details for: Air Cylinders; 750 Lb. Hydraulic; 1500 Lb. Hydraulic; Clamp Cylinders; Air Valves; Built-in Valve Type Cylinders. Complete with parts data, specifications and prices. Send today!

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2884 Bernice Road • Lansing, Illinois (Chicago Suburb)

AIR CYLINDERS • HYDRAULIC CYLINDERS • AIR VALVES
ROTARY ACTUATORS • SPECIAL CONTROLS

nification of small movements, and means of producing parallel movement. By using suitable spring strip arrangements in mechanisms, freedom from friction, play and wear of the moving parts is assured and no lubrication is required. Instrument design can often be simplified by using spring strips.

This pamphlet gives designers a knowledge of the subject which will enable them to make use of spring strips in solving certain problems in instrument design. Included are discussions on: single-spring and cross-spring pivots; parallel motion obtained with spring strips; conversion of linear motion to angular motion using spring strips; and the use of spring strips in instrument mechanisms and miscellaneous applications.

Research is People

11 x 8½ *in.*, 69 *pp. Published by New York University Press, Washington Square, New York 3, N. Y.* $4.

The Industrial Research Institute is a non-profit membership corporation, organized in 1938 by fourteen member companies interested in problems of research administration. The organization now comprises approximately 150 companies meeting twice a year to hold roundtable discussions and hear papers directed toward improving the management of industrial research.

This brochure contains a group of papers which were presented at the 51st meeting of the Institute held in April 1956. The papers are concerned with the research scientist and engineer—his recruitment, motivation, and evaluation. Authors include research directors of several major companies, professors, a university placement officer and a student.

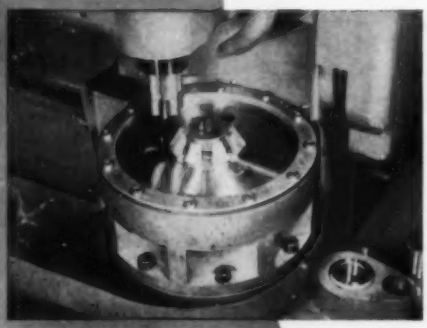
Statistical Design of Laboratory Experiments

PB 121181, Naval Ordnance Laboratory. 8 x 10½ *in.*, 102 *pp, paper-bound. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.* $2.75.

Navy-sponsored lectures on the philosophy and practical use of sta-

(Continued on page 368)

How Gear Shaper *Versatility* helps IMPROVE DESIGN

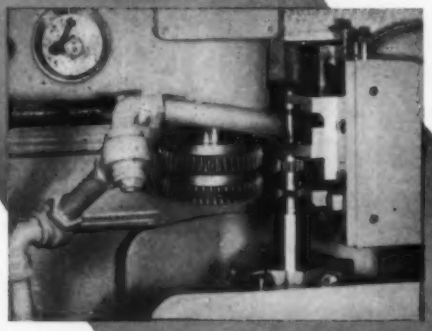


Quick-acting, air-operated diaphragm chuck speeds loading and unloading of pump rotor on Fellows No. 7A-Type Gear Shaper.

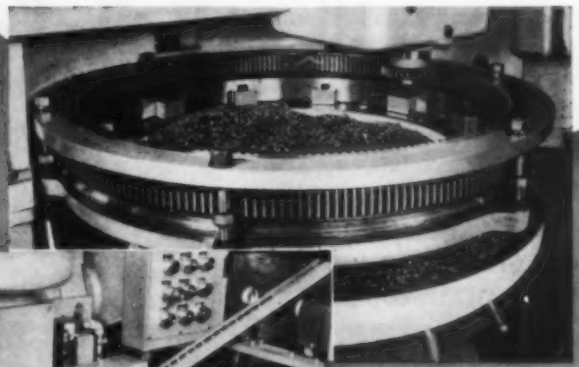
The Gear Shaper principle of generating with a reciprocating tool provides a versatile and economical method of manufacture which allows the engineer much greater latitude in the design of parts for low cost production. Special fixtures and controls permit cutting gears, intricate contours and other shapes in tandem or combination where otherwise, special-purpose machines might be required.

Free booklet — "The Art of Generating with a Reciprocating Tool" — shows in engineering detail how you can use Fellows Gear Shaper versatility to simplify and improve design. Write for it now.

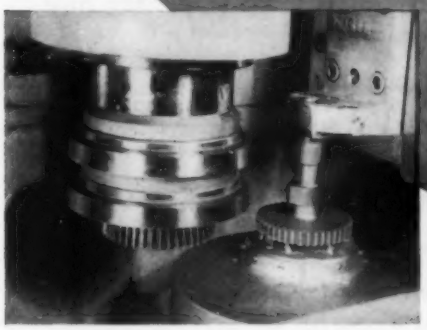
THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices: 1048 N. Woodward Ave., Royal Oak, Mich.
5835 W. North Ave., Chicago 39
150 W. Pleasant Ave., Maywood, N. J.
6214 W. Manchester Ave., Los Angeles 45



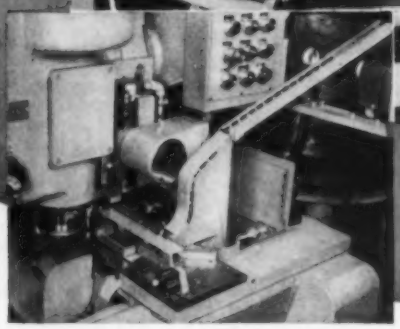
Two Gear Shaper Cutters in tandem cut automotive gears simultaneously. Center support fixture holds part in No. 4GS Gear Shaper.



Special fixture holds combination internal-external gear while internal gear is cut on 36-Type Gear Shaper.



Two cams and one gear are cut simultaneously on a gasoline motor part. Center support fixture holds part in No. 4GS Gear Shaper.



Fixture for automatically loading and unloading automotive pinions on the No. 4GS Gear Shaper.

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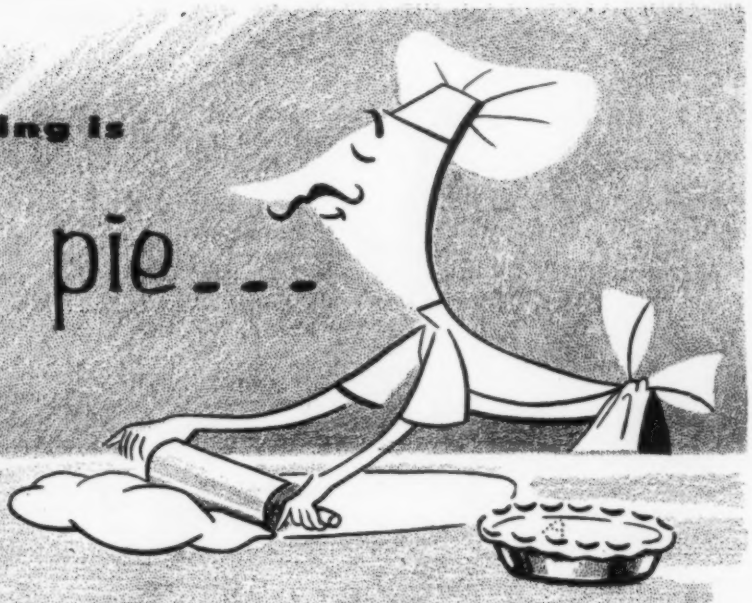

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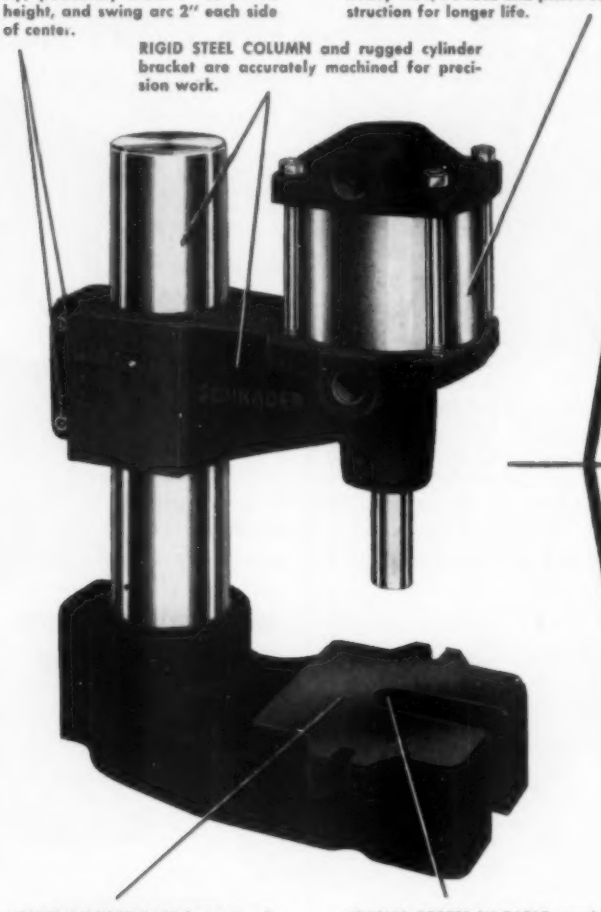

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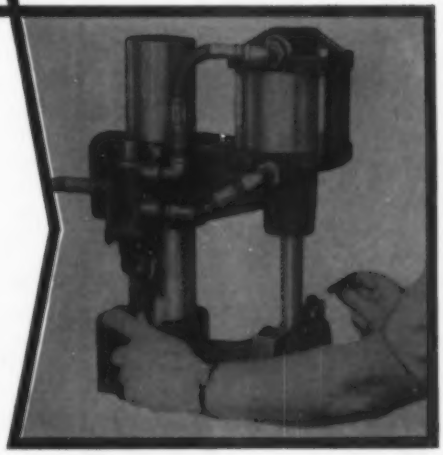

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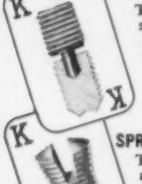

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This design is for soft metal applications. Top is "spread" slightly to take up "flow" of soft metal. Can be re-used.

Other Setko Self-Locking set screws that solve specific problems include Flush-Lok, Wedge, Truncated and Jam-Lok. A complete description of Setko set screws including Nu-Cup and Self-Tapping, and the Setko System for hopper-feeding headless set screws is contained in Catalog 21. Write today for your free copy

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tistics in research and design have been published in a single volume and made available to the public through the Office of Technical Services, U. S. Department of Commerce.

The lectures were presented by civilian statisticians during a colloquiem conducted at the Naval Ordnance Laboratory in 1954. They contain a series of viewpoints that should be useful to the engineer or scientist concerned with designing experiments and evaluating significance of the data.

Included in the report are papers on "An Example of Planning Laboratory Experiments"; "Principles of Experimental Design"; "The Student-Fisher Revolution in Modern Statistics"; "Usable but Not Widely-Known Statistical Techniques"; "Multivariate Methods in Testing of Complex Equipment"; and "Making Decisions from Experiments."

Pulse and Digital Circuits

JACOB MILLMAN, *Professor of Electrical Engineering, Columbia University* and HERBERT TAUB, *Assoc. Professor of Electrical Engineering, College of the City of New York.* 6¼ x 9¼ *in.*, 687 *pp. Published by McGraw-Hill Book Co., Inc.*, 330 W. 42 St., New York 36, N. Y. $12.50..

This provides a description and analysis of circuits and techniques common to newer fields of electrical engineering. Among the recent advances covered are: totem-pole amplifiers, distributed amplifiers, cathode interface effects in binary circuits, high-speed counting circuits, ferrite cores in pulse transformers, recent developments in video delay lines, gas counting tubes, trochotron vacuum counting tubes, basic digital computer circuits, magnetic cores in binary operation, multi-diode gate circuits, digital techniques applied to time measurements, and application of transistors in pulse and digital circuits.

The book begins with an analysis of the linear network response to waveforms commonly encountered in pulse circuits. The basic nonlinearities of tubes and semiconductor devices are described; the effects of these nonlinearities on waveform transmission are given. Waveform generating circuits, such as multivibrators, time-base

(Continued on page 372)

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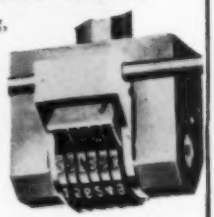

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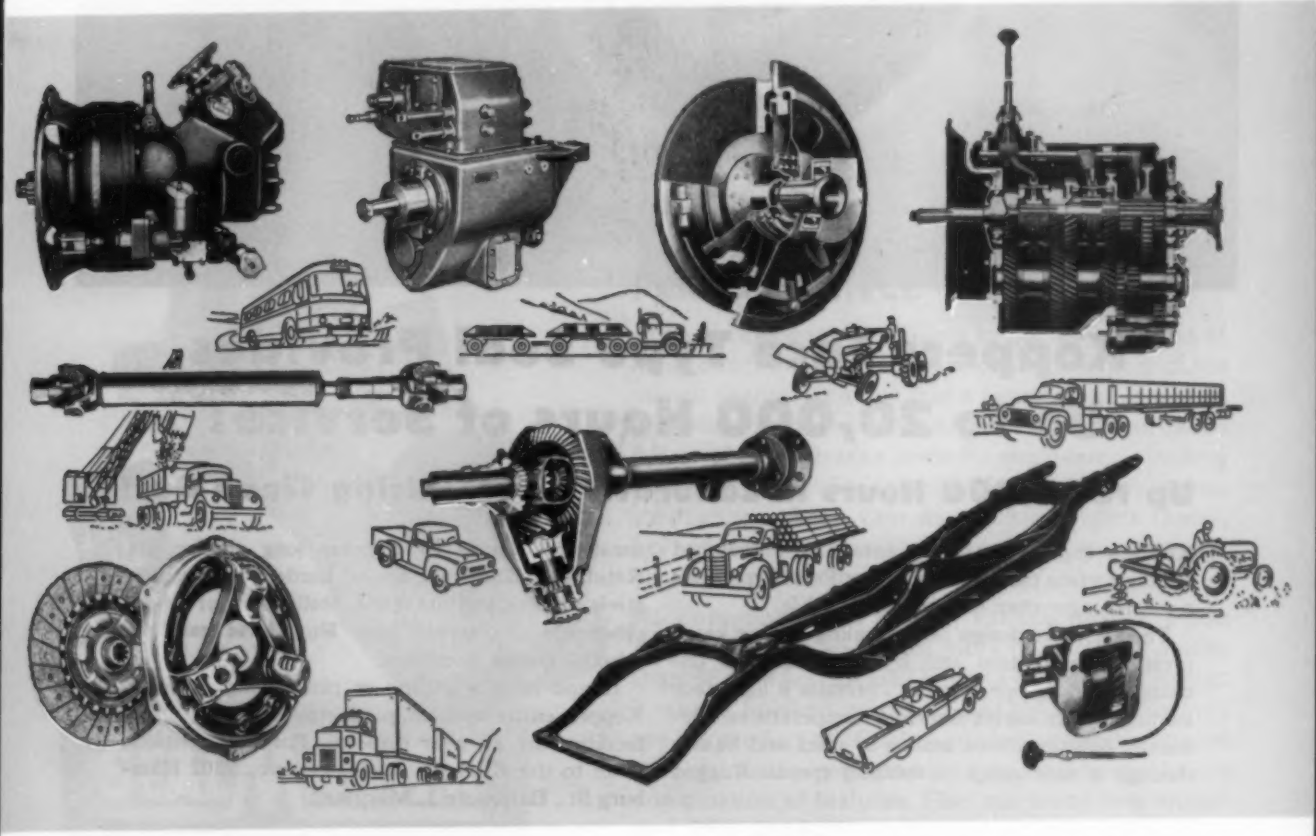

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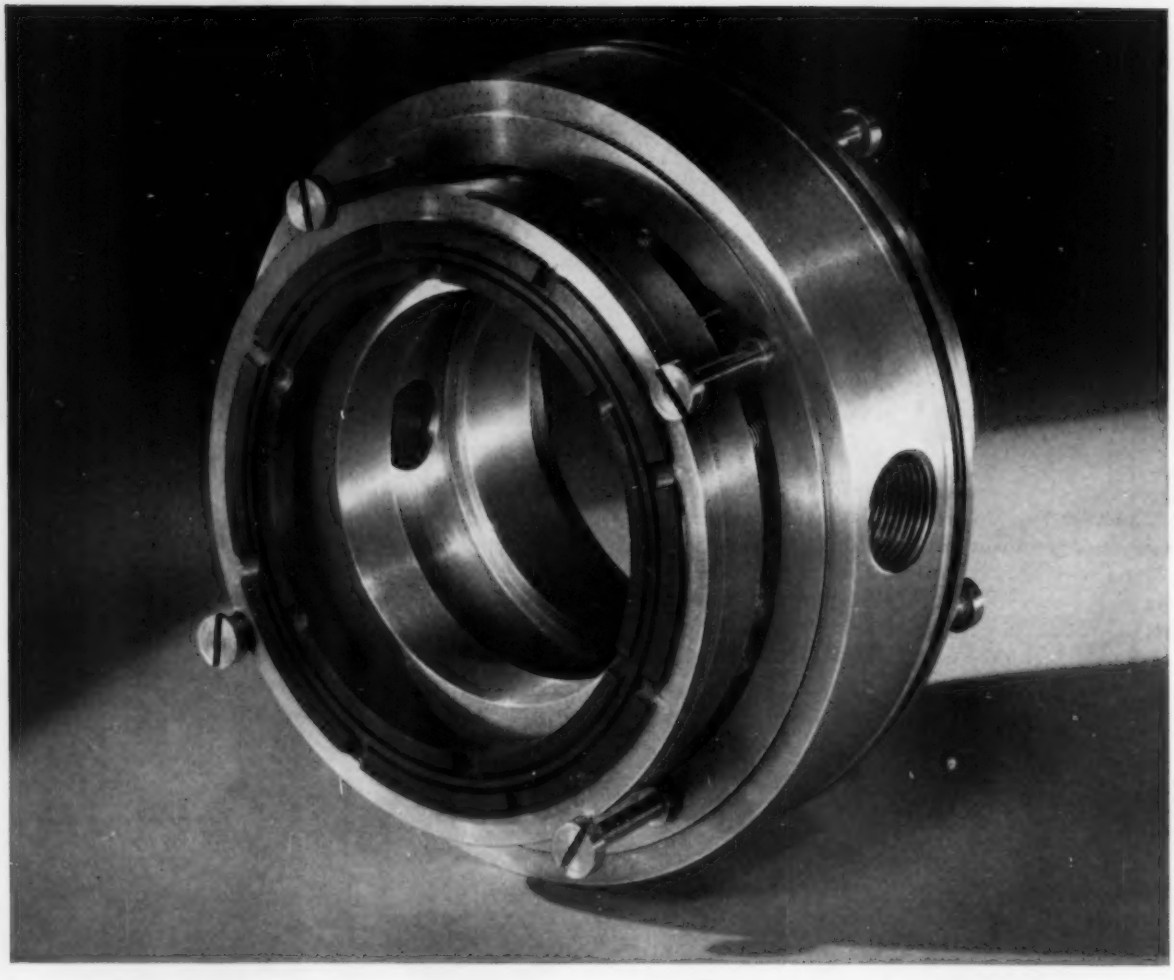

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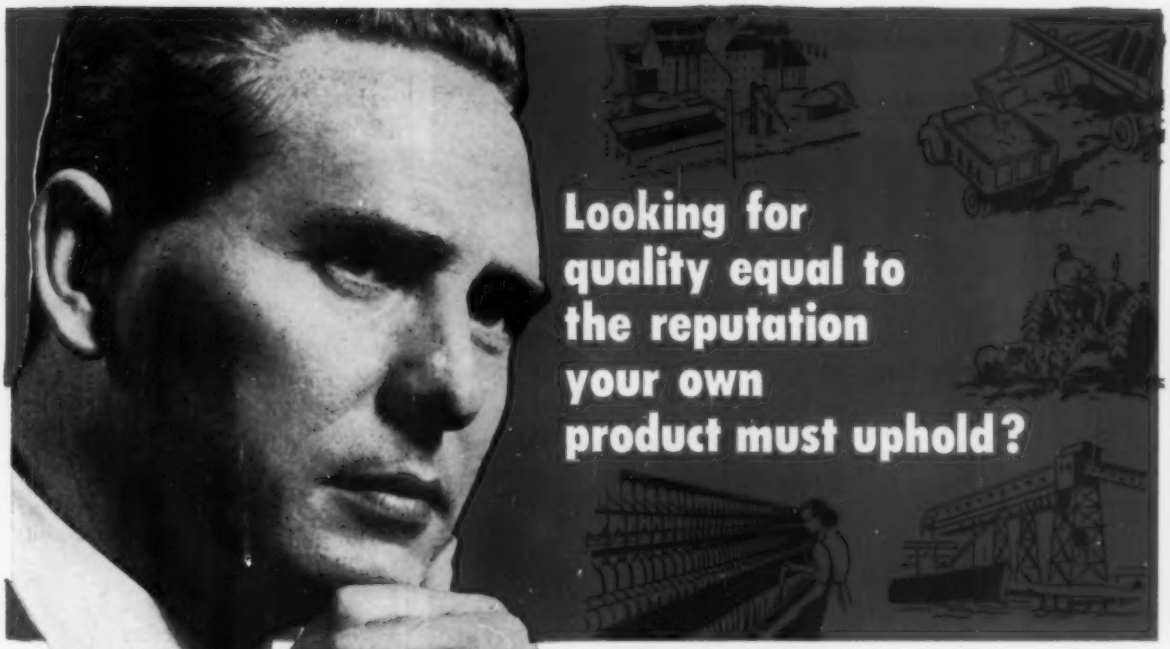

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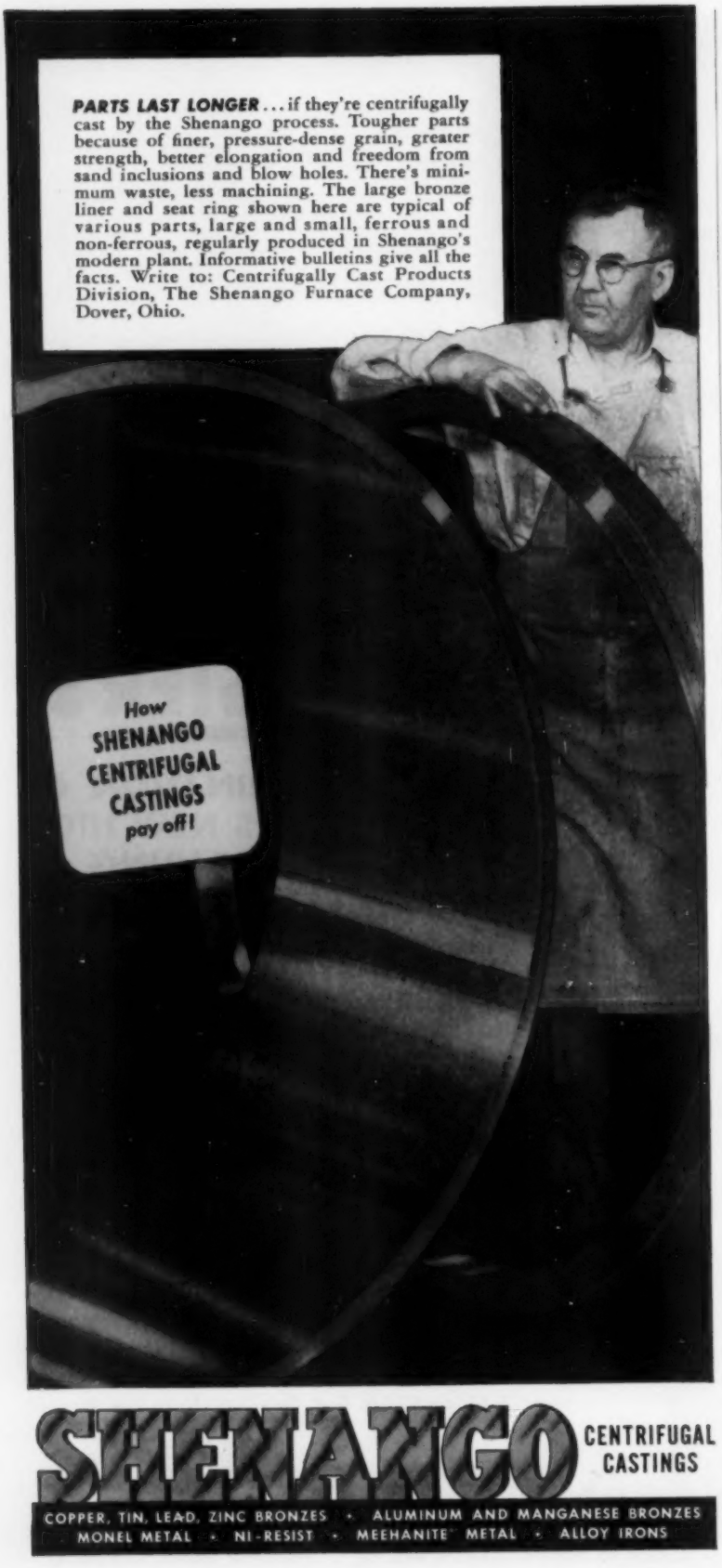
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generators, blocking oscillators and phantastrons, are analyzed in detail. Other fundamental circuits or components such as transistors, pulse transformers, delay lines, binary, gating, timing and voltage comparators, are given careful consideration. These basic building blocks are assembled into pulse and digital systems such as used in radar, television, and digital computers.

Mathematics through differential equations is used whenever required, but only after the physical motivation behind the mathematics has been discussed. A number of illustrative examples are worked out in detail. Problems, some theoretical in nature and others illustrating practical circuits and systems, are included.

Mathematics Refresher

JOHN D. CONSTANCE, *P. E. Paperbound. 11 x 8½ in., approx. 75 pp. Published by De Troy Press, Inc., Englewood, N. J.* $2.

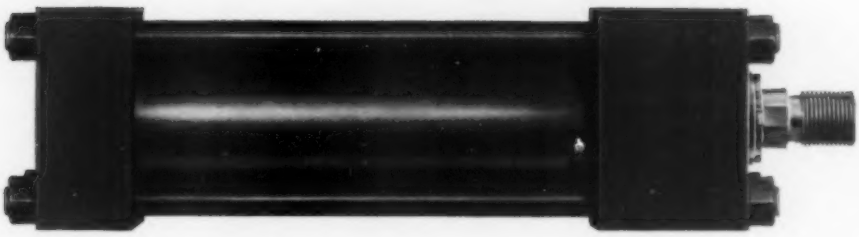
This review is intended as the basis of a refresher course, suitable for self-study, for the mathematics portion of state license examinations for professional engineer and land surveyor. Material for the development of skill both in manipulation of mathematics and practical application to engineering problems is included. Subjects covered include algebra, trigonometry, plane geometry, analytical geometry, solid geometry, spherical geometry, logarithms, calculus.

Rayleigh's Principle and Its Applications to Engineering

G. TEMPLE and W. G. BICKLEY, *5⅜ x 8 in., 156 pp, paperbound. Published by Dover Publications, Inc., 920 Broadway, New York 10, New York.* $1.50.

In recent years engineers and physicists have begun to realize the utility of Rayleigh's principle as an instrument for the rapid and direct calculation of the approximate values of critical loads and frequencies. It is well known that the approximate values determined in this way are necessarily in excess of the true value, and that,

(Continued on page 376)



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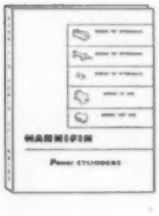

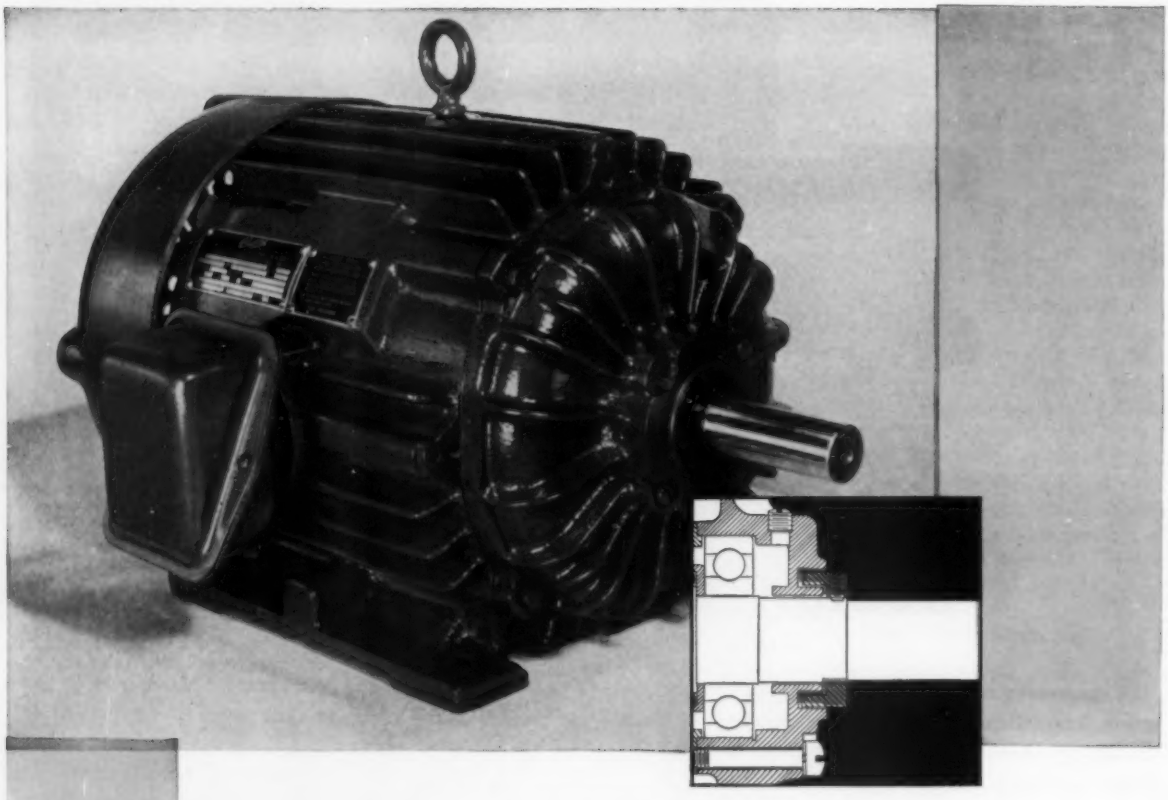

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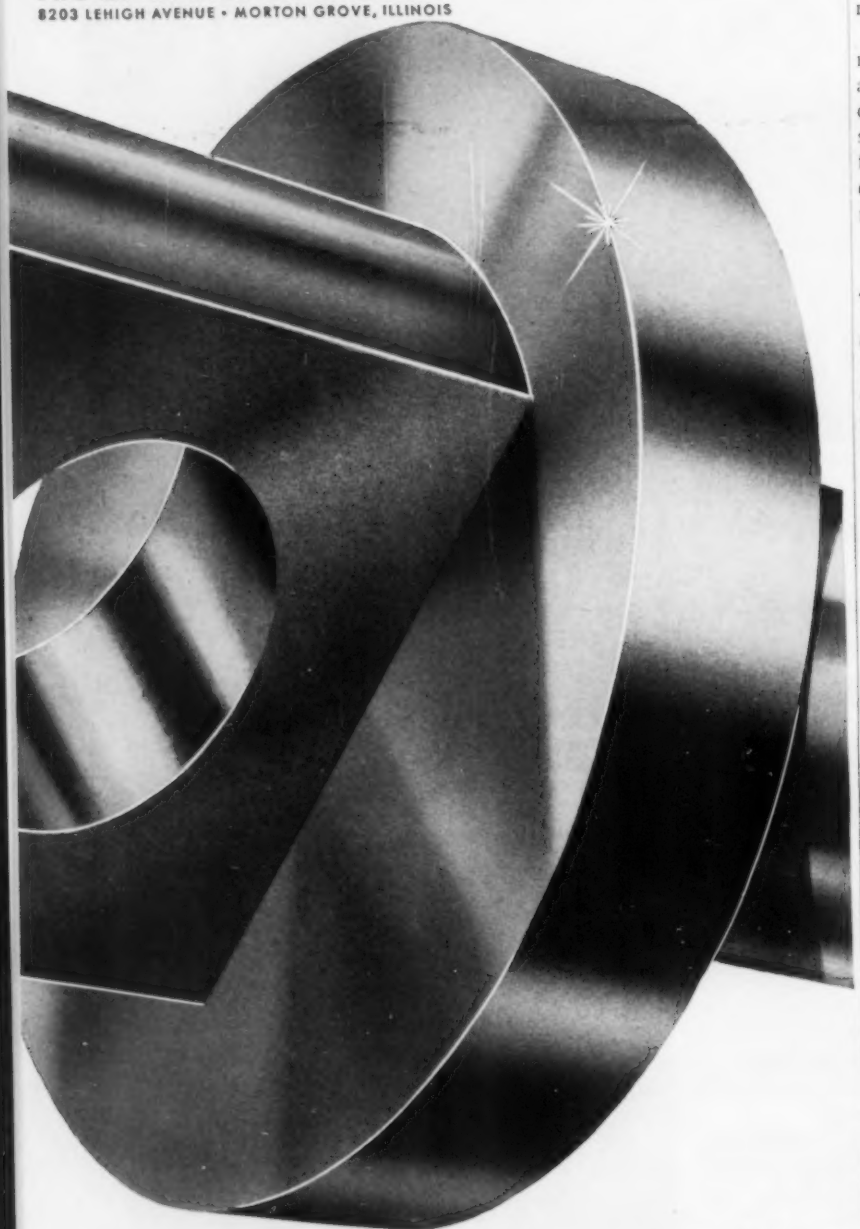

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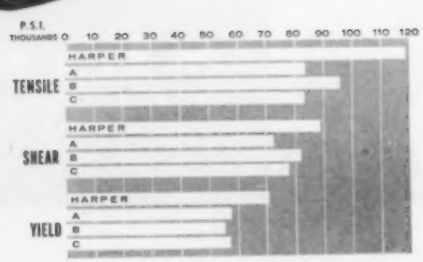

in all cases in which the true value is known, Rayleigh's approximation is well within the engineering degree of tolerance. To perfect this method of calculation all that is required is a means of calculating an approximation which is necessarily in defect of the true value, and which is as accurate as Rayleigh's upper estimate.

In this book, Rayleigh's energy method is developed in such a way as to furnish both upper and lower estimates of the true value required, so that it enables critical loads and frequencies to be determined with close and known degrees of approximation.

Technical Reports on Adhesives

Catalog CTR-300, paper bound, 8 x 10½ in., 26 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. $0.25.

This catalog lists 478 reports of research results on adhesives from government or private laboratories working under contract with the armed services or other government agencies.

Technical Reports on Rubber

Catalog CTR-321, paper bound, 8 x 10½ in., 8 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. $0.10.

This catalog lists 193 reports of research results on rubber from government or private laboratories working under contract with the armed services or other government agencies.

Materials of Engineering

Carl A. Keyser, Mechanical Engineering Dept., University of Massachusetts. 8½ x 6 in., 502 pp. Published by Prentice-Hall, Inc., Englewood Cliffs, N. J. $8.

This book is divided into three parts: metallic materials, inorganic nonmetallic materials and organic materials, occupying approximately 60, 20 and 20 per cent of the volume respectively. Though obviously written

(Continued on page 377)

for the undergraduate engineering student, the book brings together much useful information for the practicing design engineer and serves as an excellent up-to-date review of the materials field. The chapters on alloying effects in metal are particularly well-written in engineering language, and a valuable chapter on testing and failure at high temperatures has been included.

In view of the increasing importance of plastics in modern product design, more emphasis might have been placed on the organic materials by omitting the necessarily perfunctory treatment of metal extraction processes and methods of metal fabrication. An excellent bibliography is appended to each chapter, integrating the book with ASTM standards and recent materials literature. Included are books, magazine articles, and technical society papers. Summing up, this book would seem ideal for the general reference shelf.

Pursuit of Science in Revolutionary America

BROOKE HINDLE. 6x9 *in.*, 410 *pp. Published by University of N. Carolina Press, Chapel Hill, N. C.* $7.50.

This study presents an integrated discussion of the character of science in colonial America, stressing the manner in which it was organized, supported and used, and assessing the changes made in this pattern during the American revolution and the early national period. The author brings to light and interprets a vast fund of information on the scientific interests and contributions of the revolutionary generation.

Scientific endeavor during colonial days was closely connected with the development of natural history. Many of the men involved in the movement were collectors, not classifiers. Knowledge and growth, together with the tremendously important assistance rendered by European scientists broadened their activities. Scientific and intellectual organizations were developed and expanded in America; professional journals were conceived and published. The drama encompassed the work of Americans from the self-educated to those who possessed the prestige of European university

(Continued on page 381)

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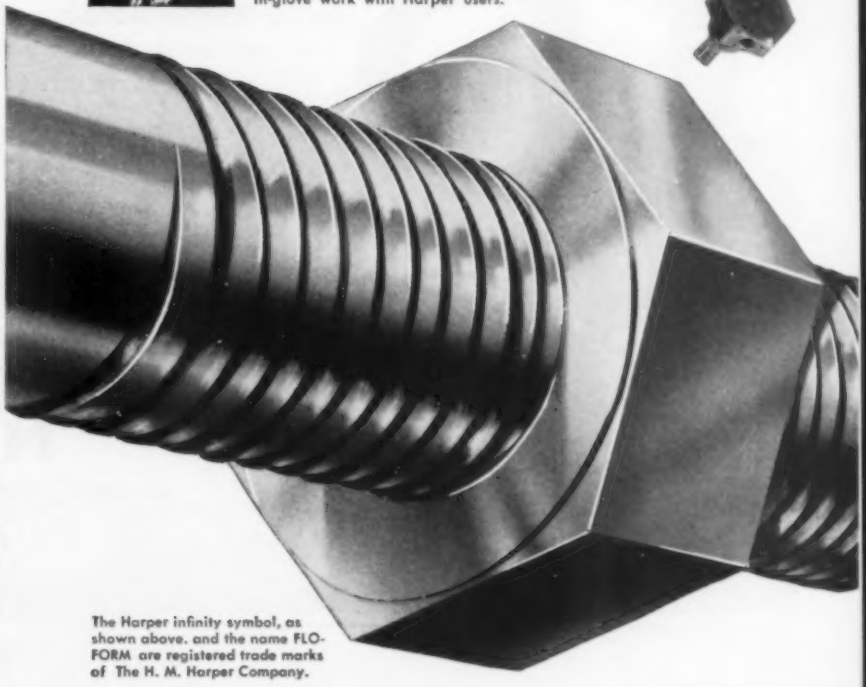

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The more automatic control problems we get, the better we like it. For while it's true each automatic control job is a bit different from the rest, the record shows that our 19 years of timer experience has given us the special knowledge it takes to give you the right answers, and in near-record time.

If one of our standard timers won't do your job — or one of the 721 combinations we have thus far developed from our 17 basic units — our engineers will go right to work to develop a new combination that's the one for you. That's the way we grow — and we like it.

We manufacture a complete line of timers in these 4 broad classifications:

TIME DELAY TIMERS • INTERVAL TIMERS
RE-CYCLING TIMERS • RUNNING TIME METERS

And since we maintain large stocks of our 17 basic units, we can assure you of rapid deliveries — of excellent deliveries even on special orders. So whatever your automatic control problem, you have everything to gain by submitting it to our timer specialists. They'll give you a profitable answer — almost with the speed of automatic control itself.

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Re-Cycling Timers

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Timers that Control the Pulse Beat of Industry

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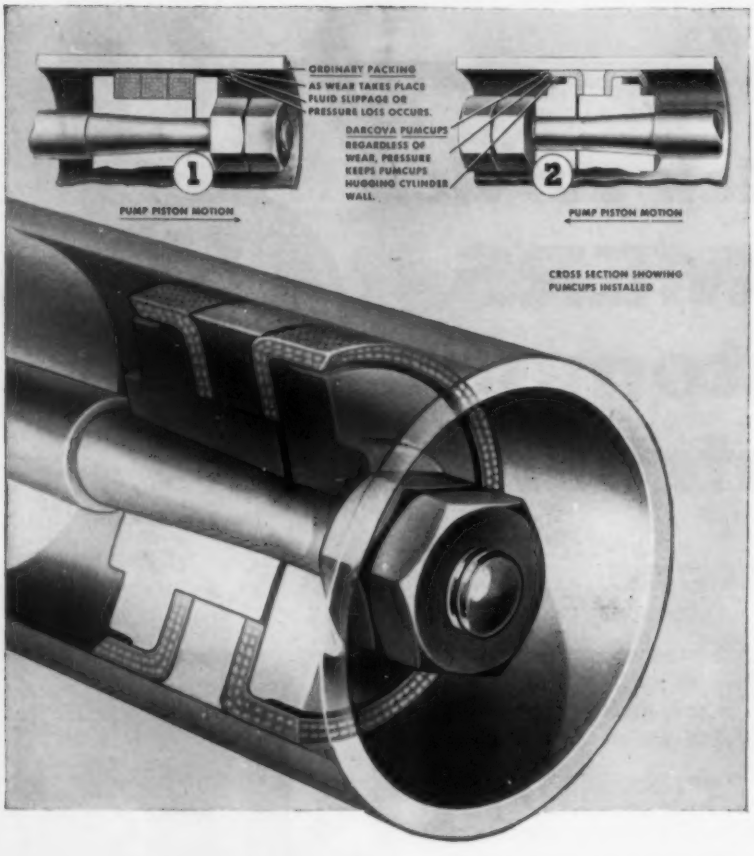
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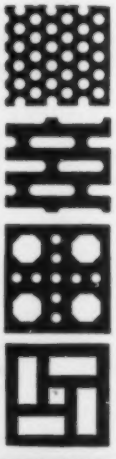

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training. Inevitably, much of the scientific knowledge of the 18th century had to come from Europe, but what was remarkable was the extent to which Americans made permanent contributions in science through the application of the methods devised in the old countries.

The author's approach is that of a social historian who demonstrates the vigor of early American scientific growth, while relating scientific developments to the movement of society from 1735 to 1789. He shows how the pursuit of science grew out of and, in turn, affected the needs and attitudes of the American people; how the Age of Enlightenment recognized no fundamental difference between knowledge of physics and astronomy and knowledge of government and economics. Major attention is accorded to the story of those who began the long climb in early American scientific history, which include such figures as John Bartram, Cadwallader Colden, Benjamin Franklin, Thomas Jefferson, Peter Kalm, David Rittenhouse, Charles Thomson, John Winthrop, and others.

Research by Nonprofit and Commercial Laboratories

8 x 10¼ *in.*, 81 *pp. Available from Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C.* $0.50.

The scientific research and development effort of nonprofit research institutes and commercial laboratories amounted to an estimated $85 million in 1953 which required the employment of about 5000 scientists and engineers, as shown in this report. The report was prepared by the Maxwell Research Center, Syracuse University, and is a part of an overall survey of the entire research and development effort in this country. It covers all the known non-profit research institutes and a substantial sample of all the commercial laboratories. The report deals mainly with general procedures and practices followed rather than detailing specific research programs and tasks.

During 1953, commercial laboratories spent approximately $35 million for scientific research, about $4 mil-

(Continued on page 385)

NEW

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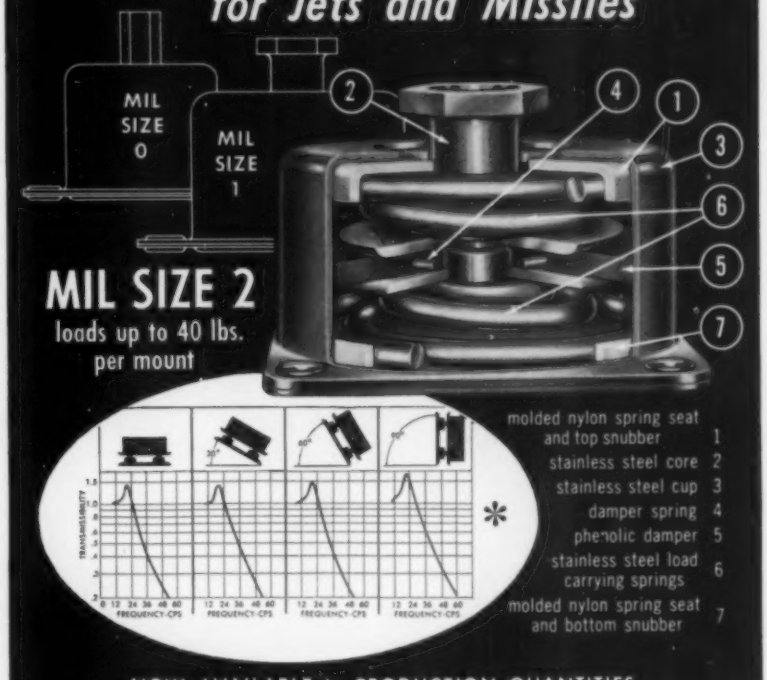

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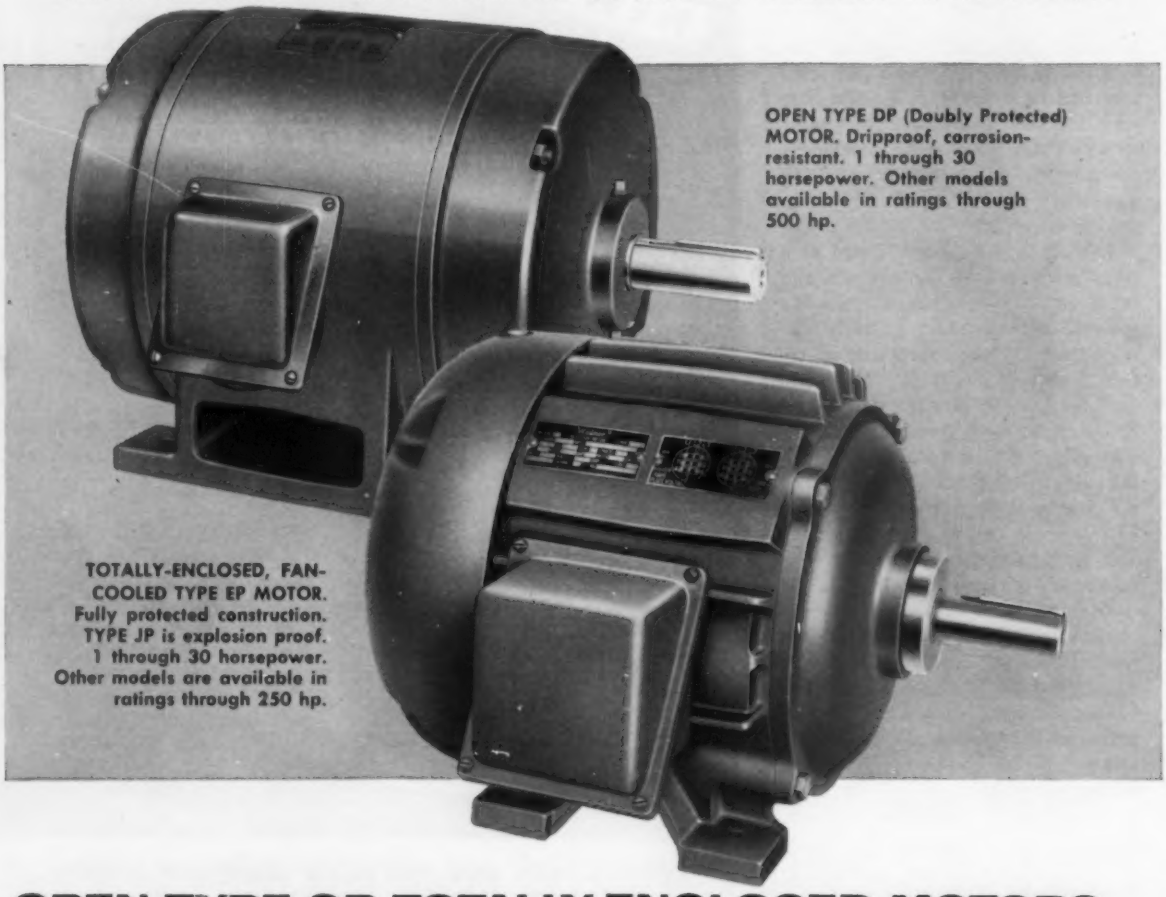

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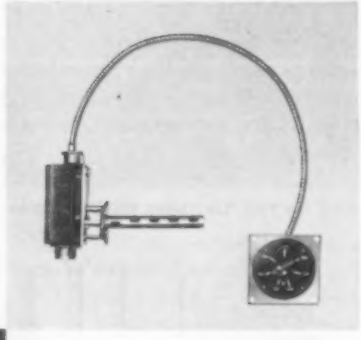

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the positive locking pin with quick release

whenever units are frequently assembled or disassembled

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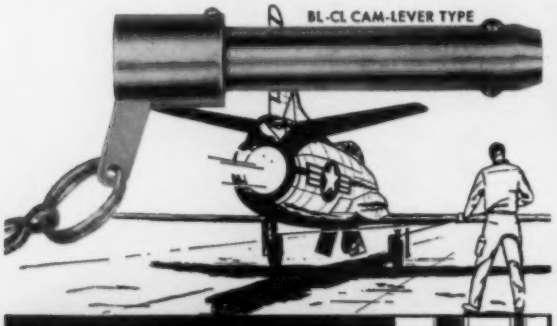

Precision BL-CL pull pins are especially adaptable for blind or hard-to-get-at places. Pin can be removed by simply pulling or attaching a cable or lanyard to pull from a distance.

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For highest dependability and safe-fast economical service . . . specify precision Ball-lok pins. The simplicity of less moving parts in the single action pins assures you of trouble-free operation. Completely eliminates all need of nuts, bolts, washers, clevis pins or other retaining items. NO TOOLS NEEDED.

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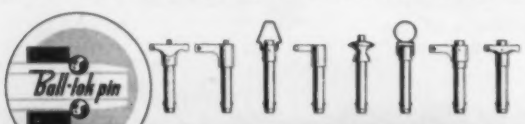

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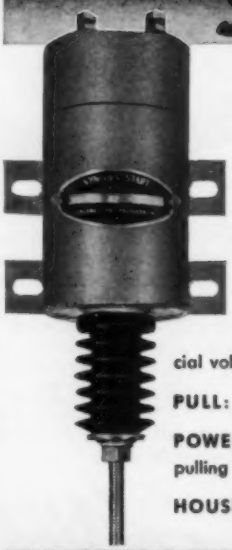

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HOUSING DIMENSIONS: 4⅛" x 2½".

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*PARTIAL REPRINT— "ELECTRICAL MANUFACTURING" April, 1956

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lion for basic research; nonprofit research institutes spent more than $50 million for research, over $3 million for basic research. Most of these organizations are of rather recent origin. In fact, the majority of the commercial laboratories and nonprofit research institutes were founded since 1941. This rapid increase can be accounted for largely by the swift expansion of the federal government's research programs, particularly those of the military departments.

The federal government contracted with the commercial laboratories for about half of their total research expenditures and industry sponsored the remainder, except for a small portion deriving from such sources as trade associations, foundations and universities. In the case of the nonprofit research institutes the government contracted for approximately twice the volume of research and development financed by industry.

Technical Reports on Adhesives

Catalog, paper bound, 8 x 10½ in., 26 pp. Available from the Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C. $0.25.

This catalog lists 478 reports of research results on adhesives from government or private laboratories working under contract with the armed services or other government agencies.

Radio Telemetry

Dr. Myron H. Nichols, *Guided Missile Research Div. of Ramo-Wooldridge Corp., Los Angeles, and* Dr. Lawrence L. Rauch, *Chairman of Instrumentation Engr. Program, University of Michigan. 9¼ x 6 in., 461 pp. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y.*

The recent rapid development of information theory has aided in the development of telemetering, now widely used in the aircraft industry and other industries for transmission, reception, and recording of data from remote locations for test or control purposes. This book includes the

(Continued on page 389)

The Clentimack transmission is a variable speed transmission for the control of any process or machine requiring variable speed. Adjustments may be made manually or automatically over a complete range 8.1 — while the unit is at a standstill or in motion.

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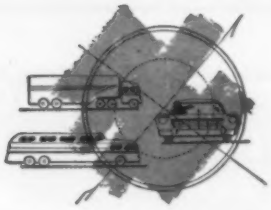

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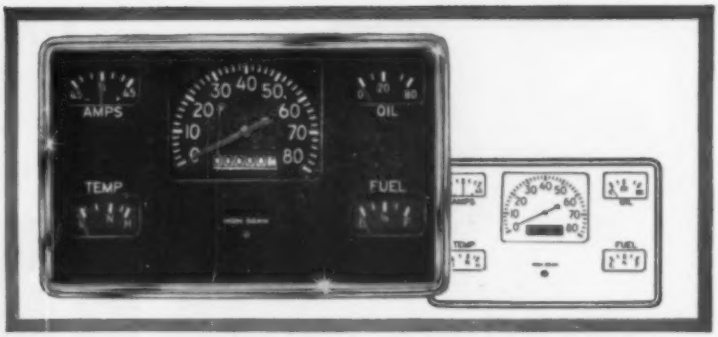
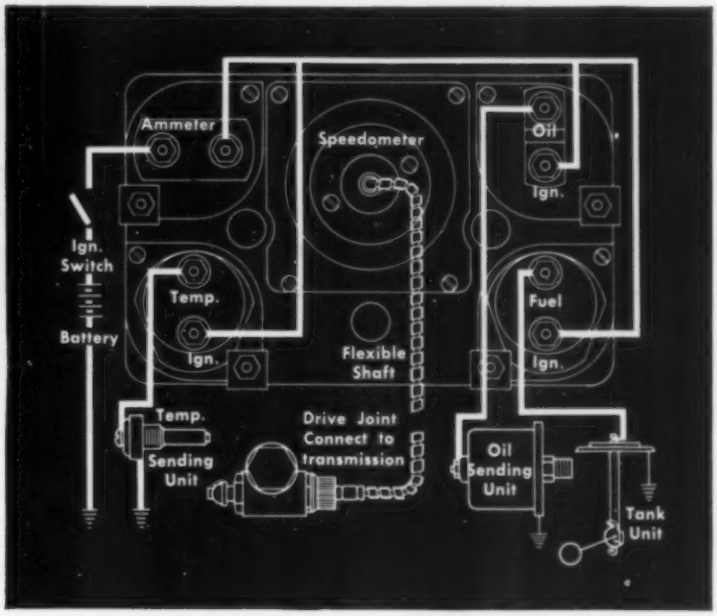


Stewart-Warner Panel 602-H. A stock panel now used by leading truck manufacturers. Highly flexible—can be fully electric or combination of electric and mechanical.



Typical Hook-up for Panel 602-H. Above panel includes mechanical speedometer, electric gauges, complete with sending units.

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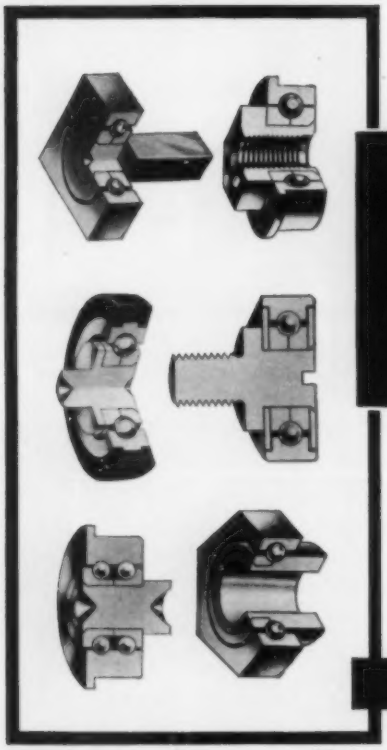

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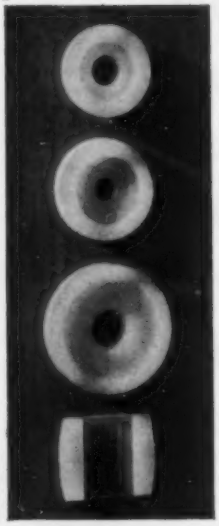

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basic theory and current practice in this field.

Although some of the material appeared in the first edition, this book is essentially a new work because of its comprehensive coverage of both practical and theoretical considerations involved in the design and development of new equipment. Detailed information is presented on environmental and inherent errors, frequency and time domain analysis, modulation and time multiplexing, minimum signal strengths and thresholds, and sampled data smoothing and interpolation.

Existing telemetering practices and equipment are analyzed and compared in terms of minimum required signal strength, crosstalk, susceptibility to environmental errors, and information efficiency.

1955 Supplement to Bibliography and Abstracts on Electrical Contacts

STP No. 56-J, 6 x 9, 48 pp. Published by ASTM, 1916 Race St., Philadelphia 3, Pa. $1.

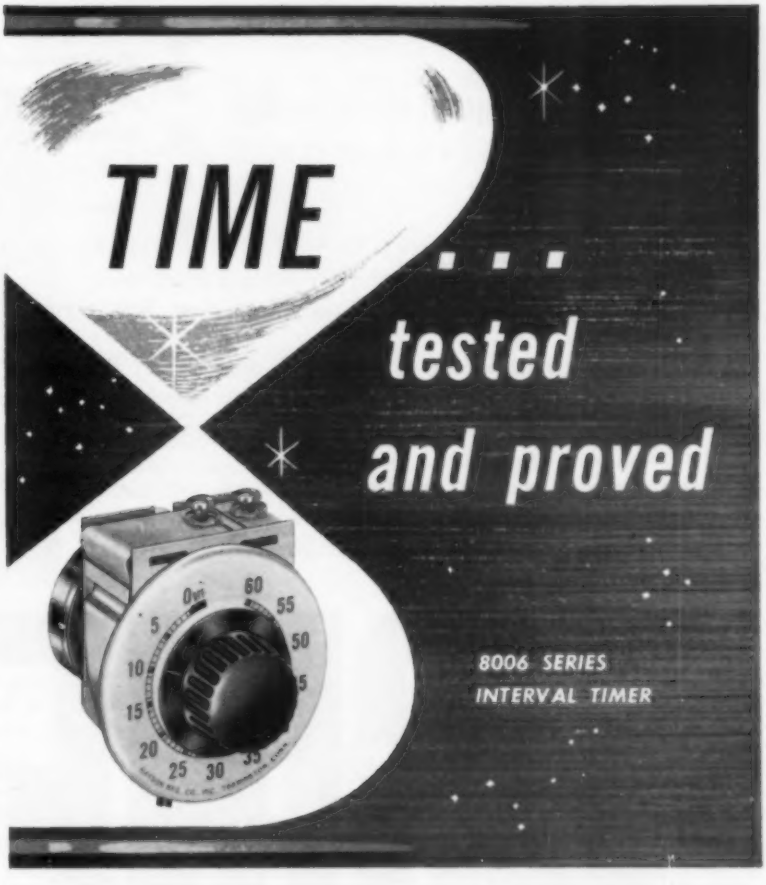
The bibliography and three supplements, of which this is the latest, each include an introduction, an author and a subject index, and a series of references on a wide variety of subjects including bridging of high current contacts in arc discharges, loading noise of carbon film resistors, conductivity of thin metallic films, friction and sliding contacts, mechanics of contact-operating mechanisms, physical and chemical properties of contact materials and ambient conditions. In the current supplement there are 16 new references for the years 1945-1953, and 168 new listings for the years 1954 and 1955.

Technical Review

BERNARD A. JOHNSON, *Project Engineer*, LEE D. SCHMID, SR., *Engineer*, and JAY WARSHAWSKY, *Technical Director*. 8½ x 11 in., 25 pp. *Published by Cook Research Laboratories, 8100 Monticello Avenue, Skokie, Ill.* $1.00.

The first part of this article is intended to provide basic information relative to the types and characteris-

(Continued on page 393)



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Gibson Refrigerator Company
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Earl Palmer, Manager of Gibson's Heating and Central Air Conditioning, points to the Rubatex strips used to seal door on their commercial central air conditioning unit. He says, "Rubatex with its closed cellular structure repels water indefinitely. Water cannot penetrate even at cut edges. And that's important toward long lasting efficiency of our air conditioning units."

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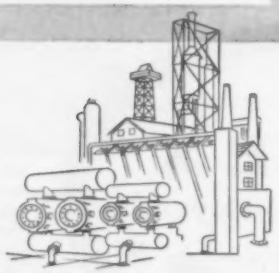

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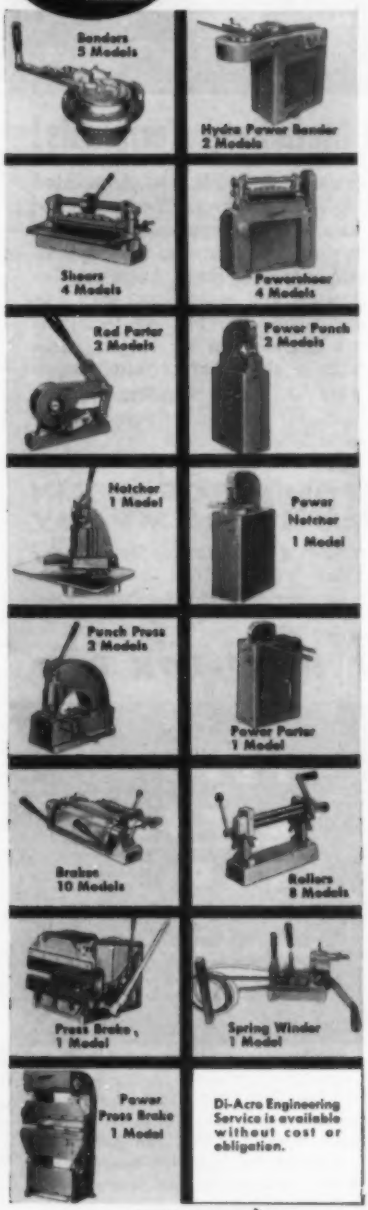

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Precision Electrical Measurements

9 x 11 *in.*, 400 *pp. Published by Philosophical Library, Inc.*, 15 *E.* 40 *St., New York* 16, *N. Y.* $12.

An international symposium, on techniques of precision electrical measurement was held in Nov. 1954, at the National Physical Laboratory, Teddington, Middlesex. Twenty-six papers were presented and discussed, and of these, four were given by authors from National Bureau of Standards, Washington, D. C.

These papers were assembled and printed unabridged in this new volume. They are divided into five parts dealing with techniques applicable to (1) electric fields and dielectrics, (2) magnetic fields and associated materials, (3) electrotechnical measurements, (4) standard techniques for high-voltage measurement and (5) for impulse-testing.

Summarized discussions appear at the end of each part. The text is well illustrated with half-tones and line drawings.

Handbook of Industrial Electronic Control Circuits

JOHN MARKUS, *Associate Editor and* VIN ZELUFF, *Managing Editor, Electronics.* 9x11¼ *in.*, 352 *pp. Published by McGraw-Hill Book Co., Inc.*, 330 *W.* 42 *St., New York* 36, *N. Y.* $8.75.

Significant industrial electronic circuits published in *Electronics* during 1948-1955 are collected in this vol-

(Continued on page 395)

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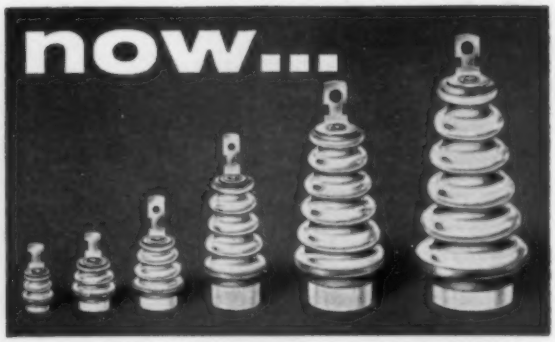

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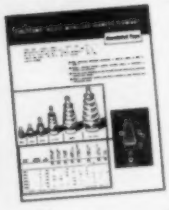

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umn. This book is a sequel to the "Handbook of Industrial Electronic Circuits" which contains circuits in use before 1948. The material in this book is organized in chapters related to different functions, and emphasizes control circuits.

Some of the main topics covered are: amplifiers; transistors; and measuring, counting, detecting, radiation, timing and ultrasonic control circuits. Included with each circuit is a brief description of the circuit, a detailed explanation of how it works, practical data on critical components, and suggested applications. Values of all important components are given. Following each circuit description is a reference to the original source.

Materials and Design for Low Temperature Service

PB121009, paperbound, 8 x 10½ in., 427 pp. Available from U. S. Dept. of Commerce, Office of Technical Services, Washington 25, D. C. $10.

In 1952 the Army Corps of Engineers held a conference on low temperature materials and associated design problems. A total of 27 authors from government and industry presented papers on all aspects of low temperature design. Finally compiled into one volume, these papers are a valuable compendium of knowledge on the subject prior to 1952. Covered are data on most of the useful low temperature alloy systems, testing methods, design criteria and a bibliography of pertinent literature.

Handbook of Electronic Measurements

Edited by Mor Wind, *Research Assistant Professor of Electrical Engineering and sponsored by General Engineering Laboratory of Rome Air Development Center, Griffiss Air Force Base, Rome, N. Y. 8¾ x 11¼ in., 879 pp (2 vol). Published by Microwave Research Institute of Polytechnic Institute of Brooklyn, 99 Livingston St., Brooklyn, N. Y. $15 per set.*

This text is written in 18 chapters by 17 authorities eminent in the field of their work. These volumes offer up-to-date, collated information on

(Continued on page 396)

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New twist in testing ...a torsional exciter

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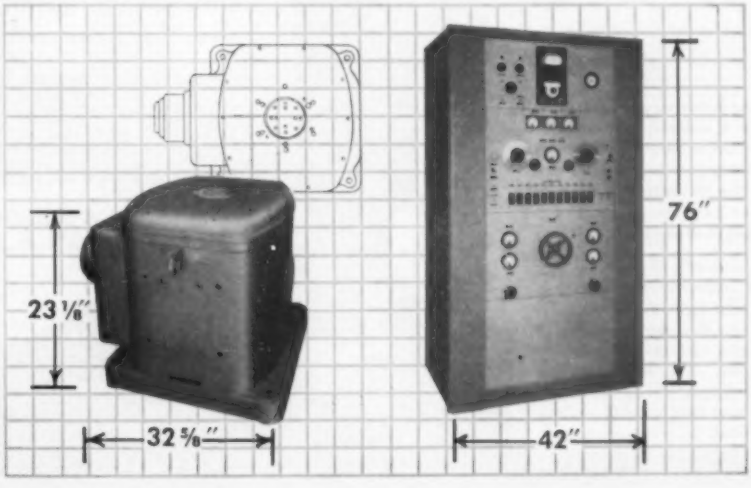

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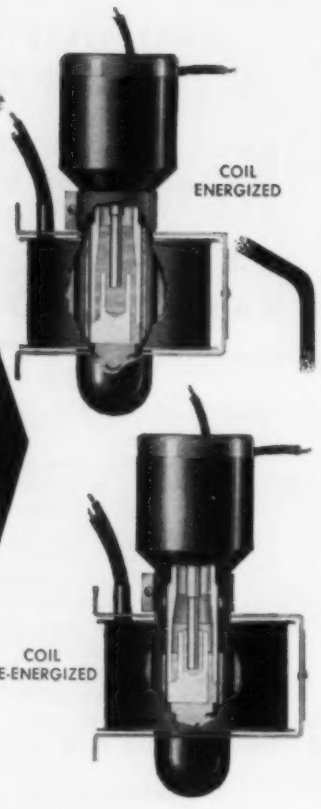

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electronic measurements and combine basic exposition with practical information. They present a compendium of measurement methods of various electrical quantities and characteristics, categorized according to frequency, from direct current through the microwave region. Complete descriptions and illustrations of necessary equipment are given and orders of accuracy and physical magnitude indicated. There are more than 600 photographs, tables, and charts.

Electronic Analog Computers

GRANINO A. KORN and THERESA M. KORN, *industrial consultants.* 6¼ x 9¼ *in.*, 452 *pp. Published by McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y.* $7.50.

A practical and comprehensive treatment of d-c analog computers, used as differential analyzers, equation solvers, simulators and control system components. How to set up problems for analog computation is shown and examples are given of practical applications, including set-up procedure,

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in typical problems of applied mathematics and engineering design.

This book also discusses how to design analog computers, covering circuit theory, components, and complete systems. Tested methods for the application of d-c analog computers as computing aids and simulators, plus detailed information and references.

Among the new advances covered in this edition are: modern simulation techniques applicable to non-linear servos and process control systems; use of diode function generators; generation of functions of several variables; computers; problem-check circuits.

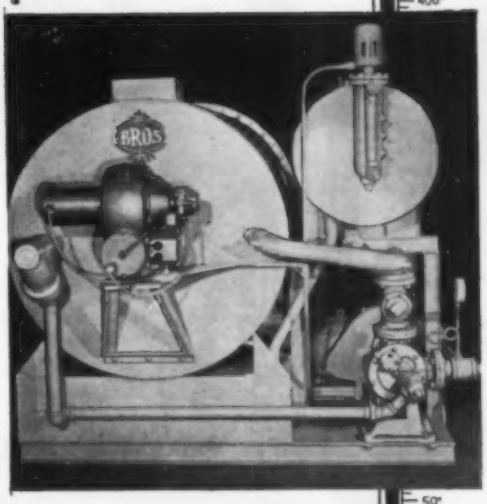
Handbook of Semiconductor Electronics

Edited by LLOYD P. HUNTER, *Senior Physicist of International Business Machines Corp. 6½ x 9¼ in., 832 pp. Available from McGraw-Hill Book Information Service, 327 W. 41 St., New York 36, N. Y. $12.*

Under the editorship of Lloyd P. Hunter, thirteen specialists of manu-

(Continued on page 399)

HOW VIKINGS PUMP OIL UP TO 500° HOT→



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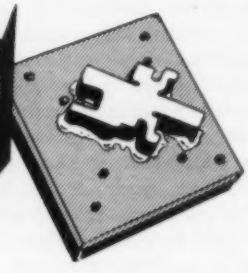

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facturers and users of semi-conductor devices have produced this new handbook covering the physics, technology, and circuit applications of transistors, diodes and photocells.

Technological processes used in transistor and diode fabrication are surveyed, including basic fabrication processes and techniques commonly used and how they achieve satisfactory device performance. Sufficient information is given to enable anyone to design and produce, in the laboratory, a satisfactory semiconductor device of average characteristics.

The larger part of the book is devoted to circuit design and applications for transistors, diodes, and photocells. Included in this section is information on such subjects as low- and high-frequency amplifiers and switching circuits; direct-coupled amplifiers; transistor oscillators; and circuits using special semi-conductor devices.

Sufficient background material is included to make it unnecessary for the reader to consult outside references to understand the main body of the text.

Oxidation-Resistant Silicon Aluminum Steels

ERIC A. BRANDES, *Fulmer Research Institute, England. Special Report No. 2, paperbound, 9¾ x 7½ in., 40 pp. Published by Fulmer Research Institute, Ltd., Stoke Poges, Bucks., England. Price, about $2.*

This report covers the development of a low alloy steel containing silicon and aluminum with an oxidation resistance in air approximating that of 18-8 stainless steel at temperatures up to 1650 F. Preferred composition is 2-3 per cent silicon and 0.5-1.5 per cent aluminum, the latter element being added to improve ductility. Hot rolling behavior was found to be very good in a commercial rolling mill; ingots up to 12 tons have been made and fabricated. The material was applied to the flame tube of the Rolls-Royce Derwent V jet engine. Preliminary tests indicate satisfactory oxidation resistance. Baffle plates for a glass-annealing furnace have lasted two years without significant scaling compared to a few days for mild steel baffles.

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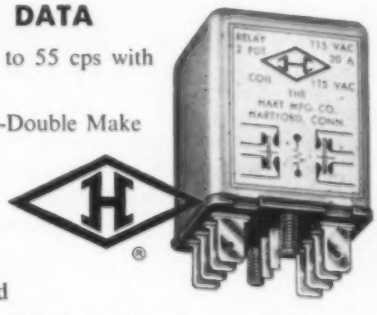

Vibration Resistance: from 10 to 55 cps with 1/16" total excursion

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Ratings: to 30 A., resistive, 115-230 V., A.C., and 1 h.p., 125 V., 2 h.p., 250 V., A.C. Other ratings on request.

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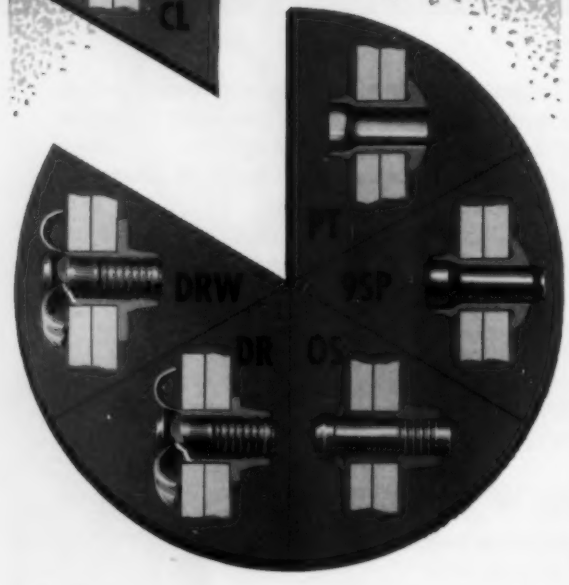

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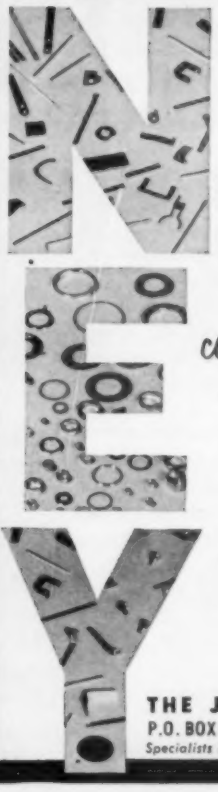

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OUR READERS SAY . . . . . .

Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

The Situation in Argentina

To the Editor:

After reading the article by Alfred Cooper entitled: "Simple Suggestions Concerning Shortage of Engineers", in the October 1956 issue of your magazine, I came to the conclusion that in the USA, as in my country, Argentina, the shortage of engineers (in spite of the difference in denomination for the same personnel existing in both countries), is due to only one fact. The engineer is not sufficiently paid, or, what is the same: the engineer is not acknowledged at his actual intellectual level!

In explanation, I refer to the situation prevailing in Argentina. In this country the technical studies are performed in three ways:

A) Schools of apprenticeship and professional orientation (under the Labor Ministry). Boys 14-18 years old, with primary studies done, work in industry while studying and obtaining a diploma as a technician (mechanics, electrotechnics, construction).

B) Industrial schools (such as Otto Krause Polytechnic School), under the Education Ministry. Boys 13-18 years old with primary school background are trained, with admission by examination. Same diplomas, plus chemical. For graduates of this school, there is also the Superior Technical Institute, annex of the Krause school, where there are specialization courses of one or two years in such fields as refrigeration, welding.

C) Colleges of engineering, architecture and sciences, associated with the University of Buenos Aires, but with the same programs and diplomas granted by the other five universities existing in the country. Engineering courses are given leading to degrees in civil, industrial, electromechanics, naval, communications, petroleum

(Continued on page 403)

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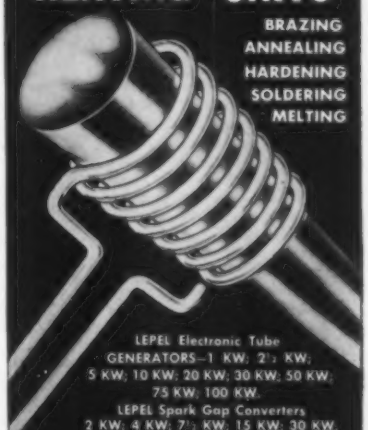

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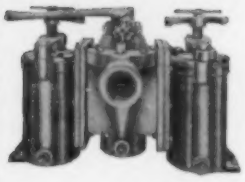

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specialties. Admission in these colleges is made with certain conditions and requirements, but it can be considered as free, except for books and other materials.

This means that the only persons able to use the title of engineer are those with university background, and that the title is considered the equivalent of a doctor's degree.

So an engineer can theoretically expect to obtain the consideration and payment for his services comparable to that received by doctors of law or medicine.

Instead, the government services and private Argentine companies prefer to pay less and hire a less-skilled or less-educated man. The private companies of foreign origin pay a little more, but it is impossible for Argentine people to be placed in positions involving top managerial functions in such enterprises.

Students about to enter the engineering college see that the amount of work and studies to be performed during the six-year course will never be adequately compensated for. Some potential students become discouraged and change their plans for an engineering career.

I can also say that a certain part in the discouragement of the students is played by the opposition of parents. These parents think engineering knowledge and achievements are one of the causes of wars. Also, the parents, too, prefer their sons to enter other professions providing earlier and greater rewards.

I agree with Mr. Cooper when he says that engineers must be relieved of drafting board duties. However, an engineer cannot be so specialized that his imagination and skill will be hampered. He must do a kind of work that will keep him in an active, creative intellectual state throughout his career.

—Robert Henning
Civil Engineer
Buenos Aires, Argentina

Correction

To the Editor:

The first four sentences of the item on page 10 of your November issue, entitled, "Combining Powder Metallurgy Procedures with Investment Casting," are basically correct,

(Continued on page 405)

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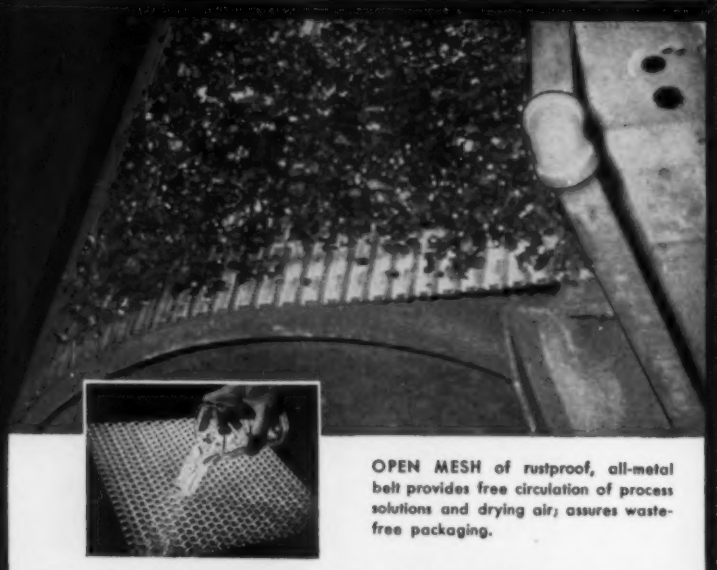

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and refer to the Sintercast Corp. materials which are used for jet engine blades and turbine buckets—in other words, for high temperature applications only. The next two sentences, starting with the words "Machinable in the annealed condition . . .," refer to another material entirely, known as Ferro-TiC.

Your next to the last sentence, beginning "The technique also permits . . .," belongs with the first four sentences on Sintercast. The last sentence in your paragraph also refers to Ferro-TiC. —JOHN L. ELLIS
Sintercast Corp. of America

Yours for the Writing

To the Editor:

I have been an interested and grateful reader of your publication for a number of years. I have had a suggestion in mind for some time but have been unable until now to write to you.

Many times I have found articles which, if available as reprints, I would have purchased. However, because of my unwillingness to enter into a series of letters to determine availability and cost, I generally do not inquire. Would it be possible to allow some small space for the listing of available reprints? —D. A. BLY
Lancaster, Pa.

Ed—A list of all reprints currently available from *Product Engineering* is enclosed. Also, we maintain a limited supply of tear-sheet copies of all articles not available in reprint form, and these copies are available upon written request as long as our supply lasts. Of course, there is no charge for these tear sheets.

To save you corresponding twice, we would suggest you send us your request for any published article of which you would like a copy. If there is a reprint charge, we will send a request-payment card along with the re-

Design Engineering Show and Symposium

Program and other details of this year's event, to take place at New York City's Coliseum, May 20-23, will be in next month's issue of *Product Engineering*.

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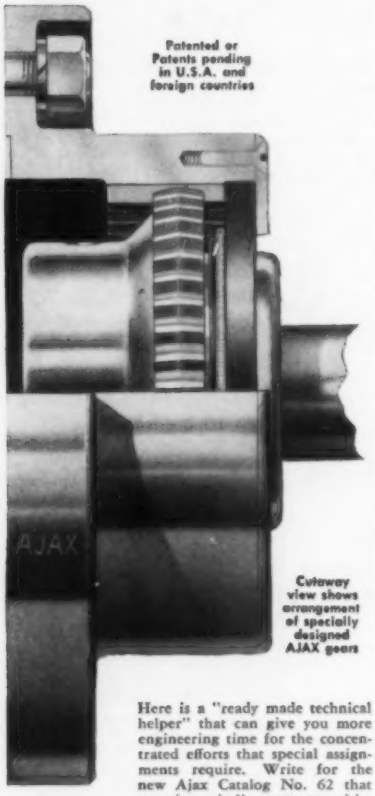

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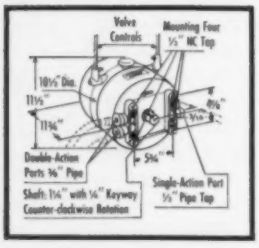

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PRESS PREVIEWS

Research Institute Formed

The formation of the Union Carbide Research Institute to engage in basic scientific research was announced by Morse G. Dial, President, of Union Carbide and Carbon Corp. Located near Tarrytown, N. Y., the institute will be under the administration of Dr. Augustus Kinzel, Vice-Pres. Research, of Union Carbide. A major purpose of the new research institute will be to contribute to the store of fundamental knowledge by studying the physical and chemical behavior of matter under ordinary as well as extreme conditions of pressure and temperature. This work at the institute will complement and extend the basic research now being carried on in the existing research laboratories of Union Carbide and Carbon Corp. It is expected that the facilities for the institute will be completed by spring of 1958. There will be 40 laboratory modules separated by movable partitions so that these units may be groups to meet changing space requirements for research projects.

New Process to Recover Titanium Scrap

Plans for the construction of a large-scale pilot plant for refining titanium scrap, using a new electrolytic

(Continued on page 409)

LOW NOISE LEVEL BRUSHES BY SUPERIOR

More and more, Industry is calling upon a Superior willingness to study a specific situation and come up with an answer that will make possible optimum brush performance.
More and more, Superior Carbon Brushes are doing a real job where noise level is an important factor.
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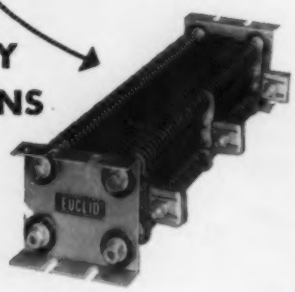
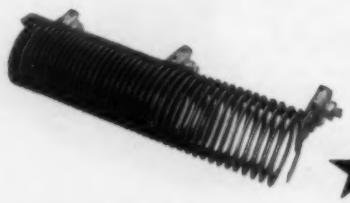
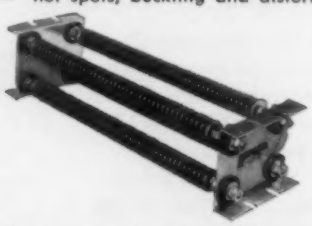


All Steel and Mica Construction provides a truly non-breakable resistor.

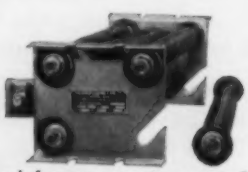


Continuous stainless steel edge-wound coil without joints eliminates hot spots, buckling and distortion.



Support rods on outside of coil permit unobstructed cooling air flow and compact design for smaller size and less weight per horsepower.

Exclusive slotted design



Slotted end frames permit removal and replacement of coil without disturbing rod assembly.

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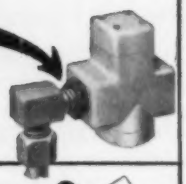


PAT. PENDING

Satisfaction Guaranteed Or Money Back TRIAL OFFER

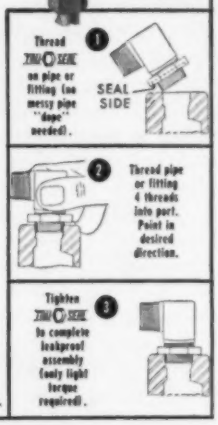
TRU-O-SEAL Fittings are guaranteed to seal pipe thread connections permanently against all oils, practically all known chemicals and gases; to seal under high pressures or vacuum; to withstand —280° to plus 500° F.; to eliminate "overtightening" damage and pipe dope. Available in ⅛" to 2½" pipe thread sizes.

$10.00 Trial Offer No. 1: eight ⅛", ten ¼", eight ⅜", ten ½" pipe thread TRU-O-SEAL Fittings.

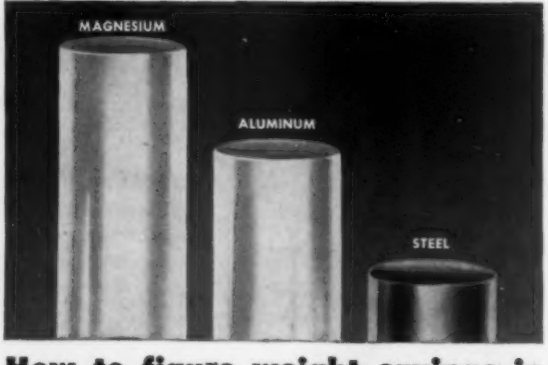
$10.00 Trial Offer No. 2: eight ½", ten ¾", four 1" pipe thread TRU-O-SEAL Fittings.

Send order to

TRU-O-SEAL DIVISION
Flick-Reedy Corporation
2002-04 N. Hawthorne Melrose Park, Ill.
"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread TRU-O-SEAL on pipe or fitting (no messy pipe "dope" needed).
SEAL SIDE
2
Thread pipe or fitting 4 threads into port. Point in desired direction.
3
Tighten TRU-O-SEAL to complete leakproof assembly (only light torque required).

Light metals design tips



How to figure weight savings in magnesium structural assemblies

Because of its unusually high strength-weight ratio, magnesium is getting more and more consideration in the design of structural units. To achieve maximum weight savings over other materials, increase the depth of the sections . . . thus maintaining equivalent strength by increasing the moment of inertia or radius of gyration.

Generally speaking, when you replace steel with magnesium a weight saving of 65% is possible under static load conditions. Under a dynamic load or rough handling, a 50% weight saving is achieved. An 18% saving is to be expected when magnesium replaces aluminum under either static or dynamic load conditions.

We welcome the opportunity to discuss weight saving possibilities with you. Magcoa engineering assistance and fabrication facilities are at your disposal.

MAGNESIUM COMPANY OF AMERICA
LIGHT METAL FABRICATION DIVISION • EAST CHICAGO 27, IND.
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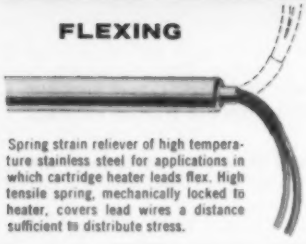
TAKE YOUR PICK!

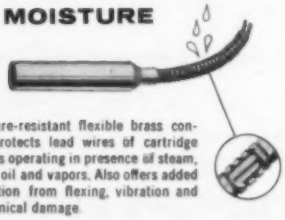
Special Chromalox features solve 3 spot heating problems

FLEXING



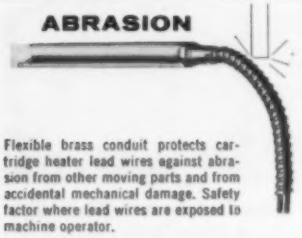
Spring strain reliever of high temperature stainless steel for applications in which cartridge heater leads flex. High tensile spring, mechanically locked to heater, covers lead wires a distance sufficient to distribute stress.

MOISTURE



Moisture-resistant flexible brass conduit protects lead wires of cartridge heaters operating in presence of steam, water, oil and vapors. Also offers added protection from flexing, vibration and mechanical damage.

ABRASION



Flexible brass conduit protects cartridge heater lead wires against abrasion from other moving parts and from accidental mechanical damage. Safety factor where lead wires are exposed to machine operator.

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CHROMALOX ELECTRIC CARTRIDGE HEATERS

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C-2101

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process that yields pure metallic titanium, has been announced by Mallory-Sharon Titanium Corp., Niles, Ohio. According to James A. Roemer, Mallory-Sharon President, the process has been proved on a laboratory scale and several hundred pounds of ductile titanium have been produced. The end product of the process consists of large crystals of pure metal, formed on a steel cathode in a heated electrolytic solution (as shown in picture). After refining, the crystals will be used in Mallory-Sharon's double-melting process in the production of conventional large ingots.

Indicative of the high purity obtained, electrolytic metal with a Brinnel hardness of 60 has been made, whereas present commercial titanium has hardness of 120 to 140. Elongations as high as 60 per cent have been achieved. This high purity may well lead to new uses for the metal, but in any event will simplify processing. The new plant is expected to be completed by June 1957.

Laboratory for Computing Systems

A research laboratory for design and development work on electronic computing systems, transistor circuits and guided missile test systems was opened by Link Aviation, Inc., Palo Alto, Calif. Under the general supervision of Earl D. Hilburn, the laboratory will have an initial operating staff of about 75 persons. One of the reasons for locating in Palo Alto was to afford the staff an opportunity to obtain advanced degrees at nearby Stanford University.

U. S. Company to Exchange Atomic Data With Canada

Authorization by the Atomic Energy Commission to exchange information and services under the U.S. bi-lateral agreement with Canada for cooperation concerning civil uses of atomic energy has been granted to the Norton Co., Worcester, Mass.

This brings the total to five U.S. companies who are now authorized to exchange data with Canada. Others

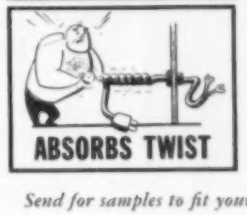
(Continued on page 411)

Tough Heyco Nylon

STRAIN RELIEF BUSHINGS

Insulate and anchor the power supply cord to your housing . . .

no need for grommets, wire knots or costly labor.



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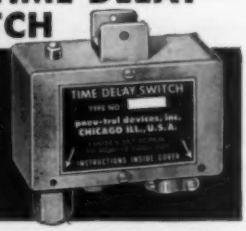
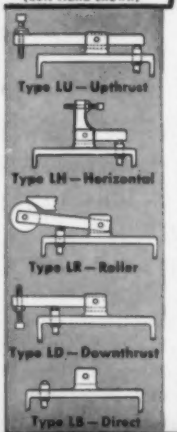
Pneu-Trol TIME DELAY CONTROL SWITCH

. . . Gives Cylinder Applications Greater Efficiency Accuracy . . . Wider Use!

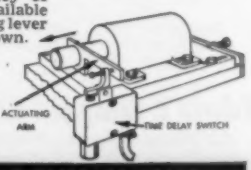


For any type actuation Left or Right Hand. (Left Hand shown)



- **Holds Cylinder dwell accurately to fraction of second.**
- **Automatically re-sets.**
- **Simple, Compact, Rugged.**

You can hold any motion or operation controlled or actuated by air or hydraulic cylinders at a positive stop on either end of the stroke for ¼ to 60 seconds in 20 to 1 ratios with Pneu-Trol Time Delay Control Switches. Simple in design with positive hydraulic timing action . . . compact and easily mounted on the machine or fixture, Pneu-Trol Switches are providing millions of trouble-free actuations in solenoid-operated cylinder applications of every type. Positive, controlled time dwell permits wider use of air or hydraulic power in automatic operations, increases accuracy of work by insuring split-second accuracy of the dwell. Available with 5 actuating lever linkages as shown.



Switch mounted to provide dwell at end of power stroke of single action, spring return cylinder.

Pneu-Trol DEVICES, INC.
1440 N. KEATING AVENUE • CHICAGO 51, ILL.

are Sylvania Electric Co., American Machine and Foundry Co., the Carboloy Dept. of General Electric Co., and Koppers Co. Under this bi-lateral agreement these companies are authorized to perform services for the Government of Canada (including the communication of secret and confidential restricted data) and to receive and possess such services from the Canadian government. Norton Company's authorization refers to the services with respect to technology of fabricating control rods, shielding materials, ceramic fuel elements, and crucibles relating to certain types of reactors.

Electric Furnace Plant

An electric furnace plant for the manufacture of boron carbide, fluid zirconia, fused magnesium oxide and fused alumia has been opened in Huntsville, Ala., by the Norton Co., Worchester, Mass. Facilities for making aluminum oxide and silicon carbide may later be added according to Edward D. Porter, Plant Manager. The plant, located on a 195 acre site, will employ about 60 people. Site chosen because of availability of low-cost electric power.

Pipe and Tubing Plant Expanded

Union Steel Corp. has begun a $9-million plant expansion at New Market, N. J., to manufacture welded stainless steel pipe and tubing. The three-stage expansion program will provide eight acres of manufacturing facilities in four buildings. The first building, having 160,000 sq ft of floor space, is expected to be completed in the latter part of 1957.

GE Converts Plant to Produce Transistors

The General Electric Company has announced that it will convert its 175,000 sq ft Buffalo, N. Y., TV picture tube plant to the manufacture of transistors early this year. In addition to the building in Buffalo which will be devoted wholly to transistor pro-

(Continued on page 413)

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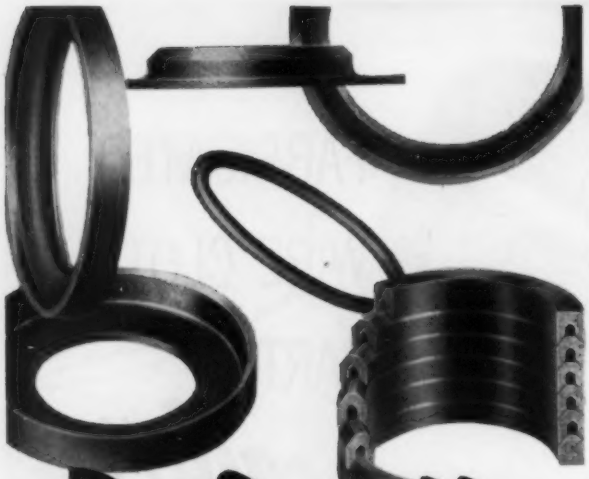

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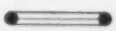
MOLDED PACKINGS

a complete line for the design engineer!

Palmetto Molded Packings comprise a complete line that encompasses every design need. Designed for you originally ...refined for you constantly...they are always abreast of latest mechanical developments. Make your choice—for better product performance:

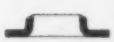
PALMETTO G-T® RING—For use as static or dynamic seal in hydraulic or pneumatic service. Seals without extruding or spiraling at all pressures to 20,000 psi. Simplifies design...reduces machining operations...minimizes overall size of equipment.

PALMETTO PYRAMID®—The champion where a multilip seal is preferred. Rugged design offers plus service life when used as a rod, ram, plunger, or piston seal at high pressures.



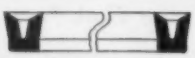
PALMETTO O-RING—A popular seal for low and medium pressures. Simplifies design—saves space. Also recommended for gasket applications.

PALMETTO KUP—A popular piston packing available in a variety of fabrications to seal the standard or new synthetic fluids. More resistant to heat than leather...will not dry out in air.



PALMETTO FLANGE—For rod packing in low pressure service. Adaptable to reciprocating or rotary motion. Also used as dust seal.

and the NEW Improved



PALMETTO U-RING—New rugged design with wide lip flare for use in cylinders made from commercial tubing honed up to .030 over nominal sizes. Same sizes available in synthetic or fabric construction permits interchangeability of packing in low or high pressure cylinders. ALLOWS STANDARDIZATION OF COMPONENT PARTS...INCREASES EFFICIENCY...REDUCES FRICTION. ALSO RECOMMENDED AS ROD SEAL.

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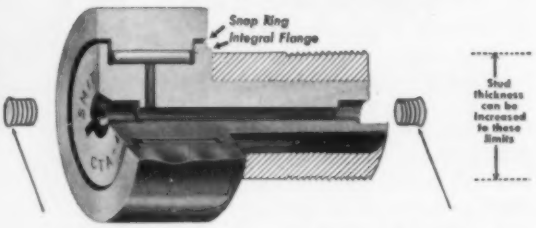

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TYPE CTA (above) is completely interchangeable with Standard bearings AT NO EXTRA COST. This unique Cam Follower has an integral flange on the stud, making it possible to increase stud diameter up to 100% greater in relation to the size of the cam roller. No other cam follower can do this. This assures extra strength where high speed and heavy load-carrying capacity are essential. A Snap Ring, which retains the roller, fits in behind the solid, integral flange. IT CANNOT BE PUSHED OUT. Let us know your maximum load. We will advise proper stud size.

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pressure balanced for easy turning

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RM REPUBLIC MANUFACTURING CO.

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duction, GE will continue to manufacture transistors at Electronics Park, Syracuse, N. Y. H. Brainard Fancher, General Manager of GE's Semiconductor Products Dept. estimated that the industry would be producing around 480 million transistors by 1965 or four thousand per cent more than in 1956.

New Electronics Laboratory

A new electronics laboratory at Maynard, Mass., with primary responsibility to design and develop airborne electronics equipment, has been formed by Raytheon Manufacturing Co. The laboratory will work on such devices as Doppler navigation instruments, aircraft intercept radars, altimeters, surface radars, and other classified items for the Defense Dept. Serving as a nucleus for the laboratory will be engineers and technical employees transferred from the firm's former aircraft systems department. The laboratory will be self-sufficient, housing all of its own supporting services as an integral part of the organization. Initially the laboratory will employ about 275 people.

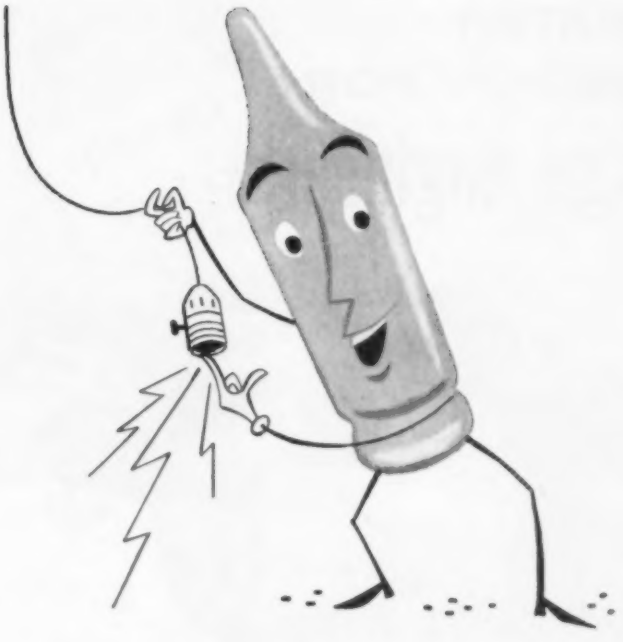
Plant for Engine Control Units

Construction has commenced on an 81,000 sq ft manufacturing plant in Phoenix, Arizona, by the Sperry Phoenix Co., a division of Sperry Rand Corp. The $3-million unit will manufacture components for flight and engine control units. The plant will employ approximately 500 persons and is expected to be completed by August of this year.

Radiation Research Building Under Construction

The Mellon Institute, Pittsburgh, Pa., has announced plans for construction of a million-dollar laboratory to house its recently established Department of Radiation Research. The two-story, double basement laboratory structure will be built on a newly acquired 125 acre rural tract near Export, Pa. Construction of the

(Continued on page 415)



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...TO SERVE AS INDICATORS

Every live circuit should have an indicator—and with radio-type resistors, G-E Glow Lamps become simple indicators that give long, uninterrupted service. Only glow lamps offer small size, low wattage, long life, wide voltage tolerance, and rugged construction—for as little as 3½¢ each! They don't fail suddenly, so there's almost no chance of false indications. All these features help make General Electric Glow Lamps the ideal choice for hundreds of applications as indicators in the electrical and electronics industries.

If you'd like more information on the amazing G-E Glow Lamps, send today for your free copy of the folder, "G-E Glow Lamps for Pilot and Indicator Use". Write: General Electric Co., Miniature Lamp Dept. PE-2, Nela Park, Cleveland 12, Ohio.

A Single G-E Glow Lamp May Serve As A:
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Because newly developed Silicone rubber compounds are capable of applications involving temperature extremes (from —130 to +600° F) they are bringing new economies to part and product design.

Rubber parts capable of withstanding temperature extremes eliminate many costly metal fabrications forced on design engineers because of the limited thermal stability of organic rubbers.

Stalwart is prepared to work with design engineers in the development of compounds as well as shapes to meet specific requirements. Whether your specifications involve extruded, molded, die cut or mandrel cut parts . . . check **FIRST WITH STALWART!**

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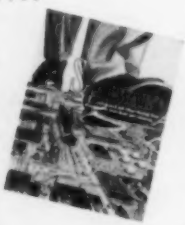

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MANUFACTURING PLANTS IN BEDFORD, OHIO AND JASPER, GEORGIA: MAIN OFFICES AT 166 NORTHFIELD RD., BEDFORD, OHIO

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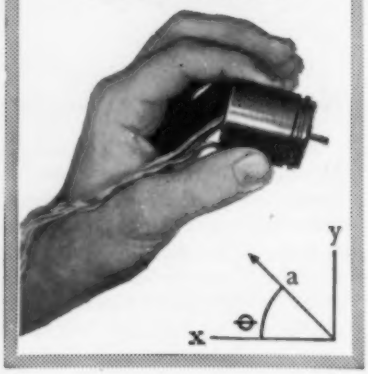
THE SIZE 15 TELESYN® RESOLVER

from FORD INSTRUMENT



- Extremely accurate computing unit
- Resolves input voltages into sine and cosine components
- Miniature size
- Lightweight
- Rated 1-24 volts, 400 cps input.

The FICo Size 15 *Telesyn* Resolver is available in models with transformation ratios of 1:1, 4:1 and 8:1. It is widely applicable in such units as analog computers, angle data transmission systems, and similar equipment.

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Ford Instrument's standard components

radiation research building is expected to be completed by late summer of 1957 and will house the Institute's first major source of radiation, a powerful 3 million volt Van de Graff accelerator. Also included will be laboratories for radiochemical and allied work, general laboratories, office space, a radiation library and equipment for using radioactive materials.

Brass Mill for West Coast

Plans for a $2.5-million West Coast brass mill have been completed by Titan Metal Mfg. Co., Bellefonte, Pa. The new mill will be erected at Newark, Calif., on a 40 acre plant site and according to company officials will be the only mill in the San Francisco Bay area producing brass rod and brass forgings.

Robertshaw-Fulton Opens Connecticut Plant

A $2-million manufacturing plant has been opened in Milford, Conn., by the Bridgeport Thermostat Div. of Robertshaw-Fulton Controls Co. The 180,000 sq ft plant, on a fifteen acre site is producing precision instruments and components for use in industry and jet aircraft as well as metallic bellows and instruments employing bellows, such as automotive thermostats and temperature controls for home appliances.

Laboratory Will Study Digital Computers

Federal Telecommunication Laboratories, a division of International Telephone and Telegraph Corp., will begin construction on the first unit of a $2.5 million, 3 building research laboratory in Los Angeles, Calif. The new laboratory will be located on a 10 acre site adjacent to facilities of another IT&T division, Federal Telephone and Radio Co., where the West Coast branch of the Federal Telecommunication Div. is now temporarily housed.

The new laboratory will be used for research and development of digital

(Continued on page 417)

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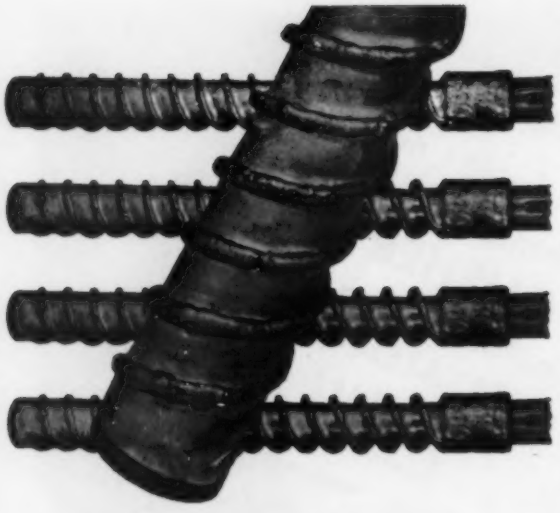

Colmonoy INCREASES Extrusion Screw Life

Tests revealed a tremendous increase in the service life of these Colmonoy hard-faced extrusion screws, as against the unprotected screws usually used. Orders for new replacements now specify Colmonoy hard-facing.

Used for extruding plastic, these screws are made of age-hardening nickel-base alloy. This alloy is now readily hard-faced with little loss of hardness, using Colmonoy No. 6 gas rod and a new Colmonoy high temperature flux.

The 60-inch screws have a .050" overlay of Colmonoy No. 6 when finish ground. Colmonoy hard-facing pays for itself in increased life very quickly on expensive parts such as these.

To provide any metal part with longer life, investigate Colmonoy alloys and methods. They represent a complete line of wear resistant alloys and the most up-to-date in hard-facing techniques.

Submit part drawings and a description of the wear encountered for a specific recommendation. Request Hard-Facing Manual No. 79.

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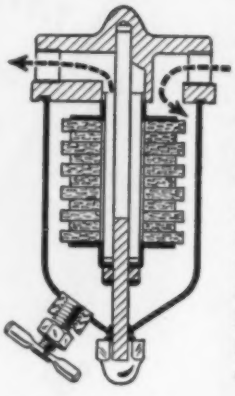
NEW MICRONIC FILTER FOR INSTRUMENT AIR



A new micronic air filter that provides extremely clean air in small volumes is now available from Air-Maze. The micron size retention efficiency is 90% for particles of .7 micron; correspondingly higher efficiency for larger particles. The filter uses extended area felt discs for fine particle filtration. Manufactured for pipe sizes from ⅛" to 1", designed to operate up to 150 psi.

The new Air-Maze micronic filter can be quickly disassembled. The felt discs are cleanable. And the housing has a petcock for removing any collected liquid.

For additional information write for data on the **Air-Maze H9S filter.**

AIR-MAZE CORPORATION
25000 Miles Road, Cleveland 28, Ohio

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. . . it's not just a saying at Henrite, it's proven fact. Engineered rubber parts—to make household appliances, business machines, electric motors and aircraft parts—quiet . . . that's our job. We've supplied leading manufacturers with rubber bonded to metal assemblies for over 25 years. Our experienced engineering laboratories, solving "noise" problems by actual test, are available to you . . . and so are the complete facilities of our Rubber Products Division and Carbon and Graphite Products Division. Write for our new informative company catalogue . . . and send along your "noise" problems. We'll look into them and suggest the proper "Henrite" cure without delay. No obligation of course.

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computers, inertial navigation systems and other electronic equipment for aircraft, as well as infra-red research. The facilities will feature ten airtight "clean rooms" equipped with electrostatic precipitators, for the infra-red and solid state physics work, and a $20,000 sideral test stand for use in gyroscopic research. The first unit of the laboratory is scheduled for completion around April, 1957, and all three buildings are expected to be in operation by 1960.

Steel Mill Controlled by Punch Cards

A punch-card-controlled steel mill, which has certain controls and speeds automatically set, is in operation at the Brackenridge Works of Allegheny Ludlum Steel Corp., Pittsburgh, Pa. The system, developed and manufactured by General Electric Co., uses punch cards with holes cut to indicate the number of passes, speed of rolling, and the sequence and amount of slab reduction. By performing the rolling operation the same each time, there is greater control of the quality of the steel. The rolled material is always of uniform size; and the steel, from day to day, has better, more constant physical properties.

In working the card system the punched cards are inserted into a card reader, a button is pushed sending electrical impulses to a master control which activates the mill. A card can contain as many as fifteen programmed passes (with accuracies of about 1/100 in.) as well as six possible recorded speeds. The use of punched cards permits an operator to maintain a large file of schedules for a wide variety of products.

The company is also studying other mill applications for new and improved electronic techniques.

Fastener Plant For West Coast

Plans for building a $5 million plant in Santa Ana, Calif., have been announced by Standard Pressed Steel Co., Jenkintown, Pa. When completed in early 1958 the 280,000 sq ft, one-story plant building will employ

(Continued on page 419)

How Beryllium Copper Springs keep foods fresher...longer

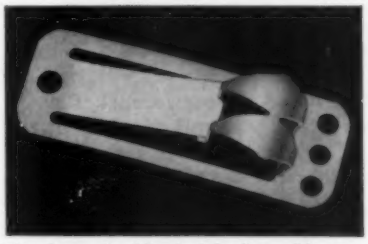
A BERYLLIUM COPPER SPRING is the "memory cell" of the defrosting mechanism of a leading household refrigerator. This small flat spring completely eliminates the necessity for remembering to defrost at the proper intervals. Thus, this beryllium copper spring functions in the defrosting timing cycle of the refrigerator — and through this increased efficiency, it helps keep foods fresher . . . longer.

The design engineers set rigid specifications for this defroster-actuating spring. They wanted, above all, maximum dependability and long life. The production department insisted on early and frequent deliveries after design details had been settled . . . and they wanted them in large quantities. And, naturally, the purchasing office demanded lower unit costs!

There's nothing too exceptional about these specifications. But there *is*, we believe, an unusual story in the manner in which they were exceeded—*on every count!*

I-S Micro-Processed Springs of Beryllium Copper

were chosen and are still being used for this installation because of their 4-way superiority:



You have the identical basic problems—time and unit costs, plus product performance. We feel that this particular spring application, clearly demonstrates two important Instrument Specialty features: *(1) our ability to produce a better spring, faster and usually at lower cost to you. (2) the specialized ability of our engineers to cooperate with your designers in meeting practically any exceptional problem that involves spring-making.*

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(*3*) THIS SAME I-S EXCLUSIVE STRIP DESIGN showed further savings in subsequent assembly-line operations—such as cleaning, inspection and attaching of the silver contacts and elimination of costly hand adjustments.

(*4*) ONLY I-S EXCLUSIVE TECHNIQUES, methods and patented equipment could have produced these far superior springs within the time limits set by the production department.

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approximately 500 people in the manufacture of a variety of the company's present and future products. The concern currently produces precision industrial and aircraft fasteneners, related specialty items and pressed steel shop equipment.

The plant will be a functional, multi-produce manufacturing facility capable of switching efficiently from one product to another. Versatility of the new plant was dictated in part by the number of new products recently developed by the company's research laboratories, some or all of which may be produced on the West Coast. Two of these new products, lightweight titanium fasteners and high-strength steel bolts, already are in production at the Jenkintown plant.

The new plant is expected to considerably reduce the lead time on deliveries to West Coast customers.

Electric Furnace to Start Expansion Program

A seventy-five ton electric steelmaking furnace will augment the open hearth furnaces at Erie Forge and Steel Corp., Erie, Pa., as part of a $4-million expansion and modernization program. The expansion which will be started immediately, is part of a two-stage program. According to E. H. Lang, Pres., the second stage will include the addition of another 75-ton and 15 ton electric furnace. When completed these facilities are expected to more than double the company's steelmaking capacity, which is presently rated at 234,000 net tons a year.

Bell Labs to Have Nuclear Reactor

Plans are being made to build a nuclear reactor at the Bell Telephone Labs, Whippany, N. J. Provided by the Air Force, the objectives of the facility are to make available more information about the electric, magnetic, and structural properties of solids, and to study the effects of nuclear radiation on various materials and components used in military electronic systems.

The reactor planned will be of the same type as one now under construc-

(Continued on page 421)

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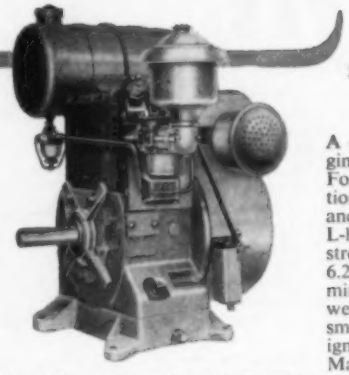

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5.5 H.P.

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Overall dimensions: *Length (incl. shaft) 15⅛", height (with tank) 20"; Width 20¼".* **Weight:** *(Dry with accessories) 86 pounds.* **Power take-off:** *Crankshaft extension 3¼" long, 1" diameter.*

MODEL CCK

Two-cylinder, gasoline-powered

12.9 H.P.

Horizontal, two-cylinder opposed design gives this engine exceptionally smooth, quiet operation. Develops 12.9 H.P. with accessories at 2700 R.P.M. Pressure air-cooled; 4-cycle; 3¼" bore; 3" stroke; 50 cubic-inch piston displacement; 5.5:1 compression ratio. Extra-large bearing surfaces; high tension magneto ignition; governor regulation within 5%. Short, extra heavy crankshaft. Removable aluminum cylinder heads. Full pressure lubrication. Manual pull-rope starting. (Recoil starter optional).

Overall dimensions: *Length (incl. shaft) 14¾", Width 19½", Height 17⅞".* **Weight:** *(Dry, with std. accessories) 148 pounds.* **Power take-off:** *Crankshaft extension, 21⅜" long, 1½" diameter.*

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Two-cylinder, air-cooled Diesel

15 H.P.

Where heavy duty performance, economy and safety are important factors, this air-cooled full Diesel engine has outstanding advantages. Electric starting; horizontal, 2-cylinder opposed design; develops 15 H.P. with accessories at 2300 R.P.M.; 4-cycle; 3½" bore; 3½" stroke; 67.3 cubic inch piston displacement; 17.3:1 compression ratio; forged steel crankshaft and connecting rods; extra-large bearing surfaces; full pressure lubrication; 12-volt generator.

Overall dimensions: *Length (incl. shaft) 26¼", Height 28"; Width 30¼".* **Weight:** *(Dry, with accessories) 516 pounds.* **Power take-off:** *Flywheel for disc drive; accessory crankshaft extension 4" long by 1½" diameter.*

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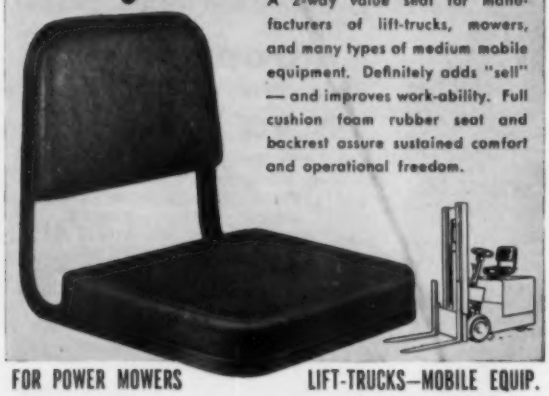

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tion at Massachusetts Institute of Technology, Cambridge, Mass. If the plans for the program are approved by the Air Force, construction will begin this year and will require over a year to complete. In the meantime, outside facilities may be utilized for the program. A license application will be made to the AEC for a heavy water moderated heterogenous fuel reactor, similar to one originally developed at the Argonne National Laboratory, Lemont, Ill.

New Divisions

Aluminum Company of America, Pittsburgh, Pa., has established a Power Engineering Division in order to combine the activities of the hydraulic engineering division and the steam power activities of the mechanical engineering division.

Flight Research, Inc., Richmond, Va., manufacturers of photographic data recording instrumentation and business aircraft controls, has established a division for the manufacture of single crystal silicon. This product will be used in rectifier, transistor and solar batteries.

General Electric Co., Schenectady, N. Y., has announced the formation of two new motor departments. The company's Medium Induction Motor Dept. is being divided into Medium a-c Motor and Generator Dept. and Small a-c Motor and Generator Dept.

Minnesota Mining and Manufacturing Co., has established an Engineering and Staff Manufacturing division in order to provide more effective service to the company.

Tait Manufacturing Co. Dayton, Ohio, has announced the formation of the Taitco Division which will handle products and accessories made by Tait for other manufacturers.

Name Changes

International Automatic Electric Corp. has changed its name to Automatic Electric International, Inc.

Kelsey-Hayes Wheel Co. has changed its name to Kelsey-Hayes Co. as the former name is no longer descriptive of the company's business.

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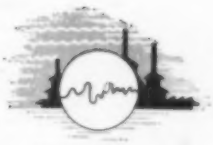
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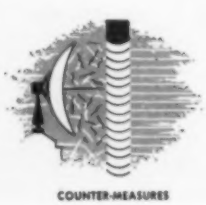
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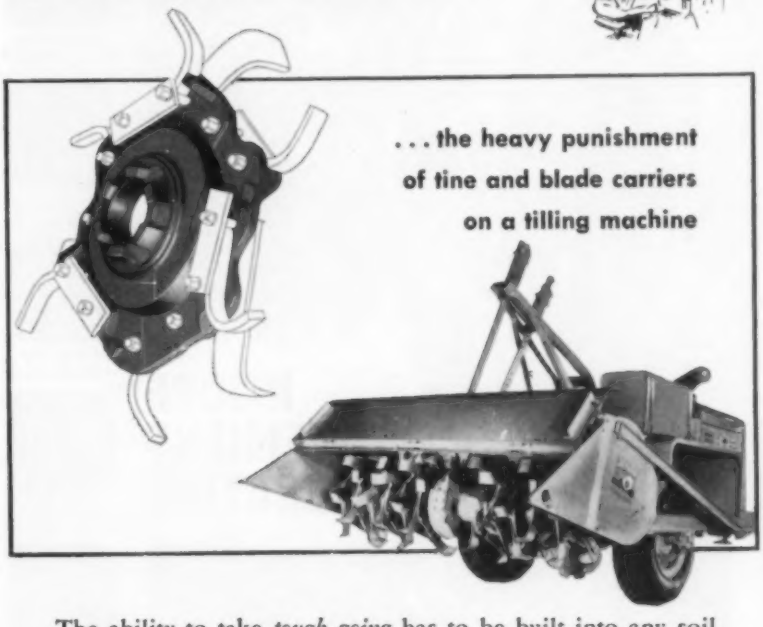
It's the solution to many problems like this one



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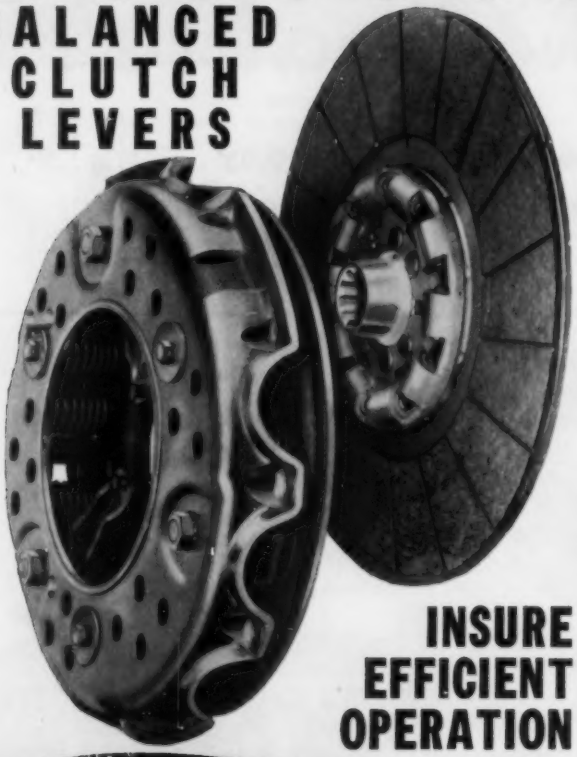

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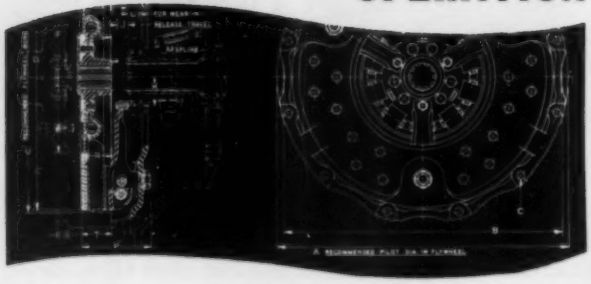

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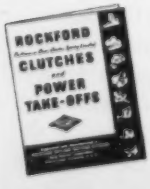

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CLUTCHES

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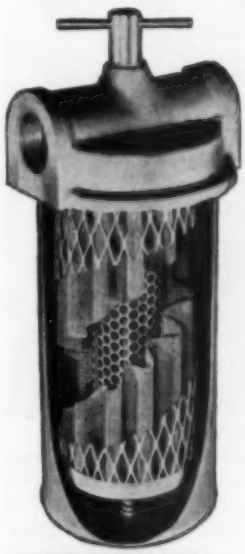
Here's What Users Have to Say About MARVEL *Synclinal* FILTERS

SUMP TYPE (cutaway)



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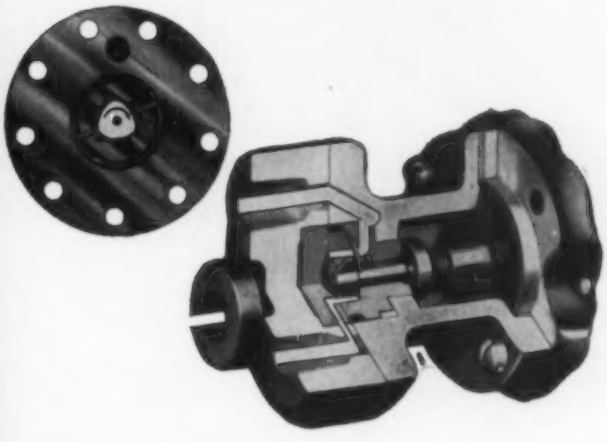

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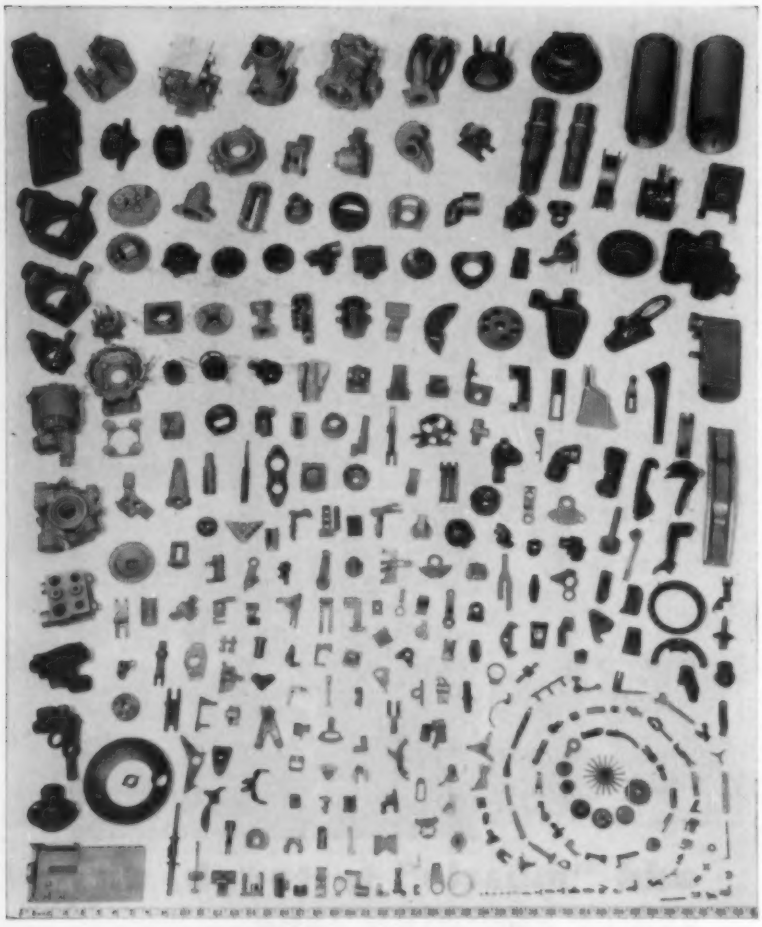

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Investment Castings

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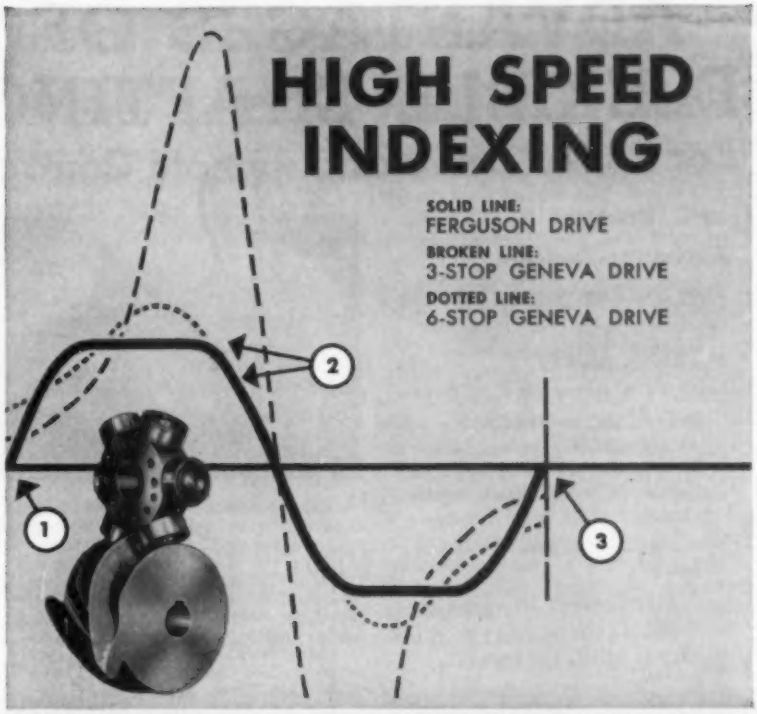

FERGUSON DRIVES VS. GENEVA DRIVES

MODIFIED TRAPEZOID ACCELERATION CHARACTERISTIC OF THE FERGUSON DRIVE PERMITS SPEEDS UP TO 1,000 INDEXES A MINUTE!

The acceleration diagrams above show why it is practical to operate the smooth indexing Ferguson Drive at a rate far beyond that of the obsolete geneva drive. As every engineer knows, the geneva limits the speed of production machinery . . . the clanging, banging and jarring wears out the geneva drive and the machine, and affects product quality.

Now see how the Ferguson Drive differs!

1. *The Ferguson Drive has an initial force of zero with a sinusoidal increase . . . the start of the movement is smooth.* Genevas have instantaneously applied dynamic forces, followers "crash" into slots, whatever accuracy existed is soon lost.
2. *The Ferguson Drive, utilizing a combined cycloidal and gravity curve, has a very low maximum acceleration value with a gradual change to maximum deceleration.* The geneva has a high maximum acceleration value with an almost instantaneous change. Vibrations from the geneva drive decrease efficiency of the machine and create a need for excessive maintenance.
3. *Deceleration and stopping of the Ferguson Drive is gradual.* Geneva drives decelerate suddenly . . . they practically "jerk" to a stop and the shock is tremendous at high speeds.

Differences in precision, life expectancy and design versatility of the two types of mechanisms are equally striking. They are discussed in our new Catalog 106 on STOCK AND STANDARD FERGUSON DRIVES. Send for your copy if you are an engineer interested in learning about high speed indexing methods.

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ADVANTAGES OF FLEXIBLE SHAFTING

For Power Drive and Remote Control

by C. Hotchkiss, Jr.
Application Engineer,
Stow Manufacturing Company

Flexible shafting has the following advantages over other type drives:

1—it is often the simplest method of transmitting power between two points which are not collinear or which have relative motion

2—eliminates exposed revolving parts

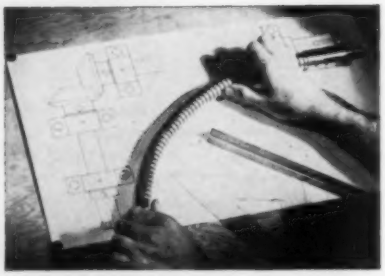
3—does not require accurate alignment

4—easy to install and maintain

Not Collinear—Where it is necessary to connect two shafts which are not collinear, a simple arrangement of a single belt or two universal joints will often do the job adequately. But, in many cases where the path of transmission is more complicated and would require a more expensive arrangement of mechanical components, flexible shafting provides a simple, low cost, efficient drive which is easy to install because it does not require accurate alignment. See example, figure 1, in which a 1¼ inch Stow flexible shaft is used to drive the auger on a G.L.F. bulk feed truck.

Flexible shafting also allows the designer greater freedom in locating either the drive or the driven component on a piece of equipment.

Fig. 1



Relative Motion—Where two shafts which have relative motion must be connected, flexible shafting is often the ideal means of transmission. In many cases it eliminates a much more complicated drive which would, necessarily, include telescopic joints; further, it eliminates the danger of exposed moving parts. See figure 2, which shows a ¾ inch Stow flexible shaft driving an Avery Rake built by the Minneapolis Moline Company.

Fig. 2

Other typical applications of this type are used on portable power tools when motors are too heavy to be mounted on the tool—such as portable grinders, sanders, paint scrapers, saws and tree tappers. And, since flexible shafting is not affected by vibration, it is an ideal drive for applications where a high degree of vibration is involved—such as in vibration testing tables and concrete vibrators.

Stow flexible shafts are available: for power drive applications in diameter sizes from ⅛ inch to 1¼ inches; for remote control applications in diameter sizes from ⅛ inch to 1⅝ inches. The 1¼ inch power drive shaft will transmit up to 10 HP while the 1⅝ inch remote control shaft will transmit up to 4000 lb. in.

For complete engineering data on flexible shafting, including selection charts, write for engineering Bulletin 570.

STOW MANUFACTURING COMPANY

426 STATE STREET, BINGHAMTON, NEW YORK

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Tough, hard ceramic coatings provide superior bearing surfaces

Sprayed alumina forms "sapphire-hard" surfaces highly resistant to wear, abrasion and corrosion. Ideal for bearing surfaces, seals.

Development of the new METCO THERMOSPRAY GUN for spraying high-melting-point ceramic materials at low cost opens up a variety of new practical applications. One that has produced a great deal of interest is the use of sprayed alumina coatings for bearing surfaces and mechanical seals. This THERMOSPRAY 101 Ceramic Powder produces surfaces with a hardness of 9.0 on the Moh scale, (only the diamond rates 10.0) with excellent resistance to wear, abrasion and corrosion. When used in combination with special phenolic or furane plastic sealers it provides superior protection against many acids.

Another THERMOSPRAY Powder – 201 – is zirconia which is somewhat softer than No. 101 but provides superior heat-insulating properties. Melting point of this material is 4600° F. and particle hardness 8.0 on the Moh scale.

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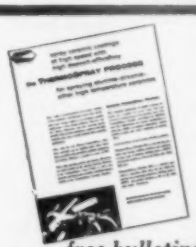
The new THERMOSPRAY GUN operates without compressed air, only oxygen and acetylene being required. The free-flowing THERMOSPRAY powders are fed to the flame nozzle from a hopper atop the gun, melted and propelled to the surface to be coated. These materials are sprayed many times faster (up to 15 sq. ft. per hour – .010" thick) than has been possible with equipment previously available. Deposit efficiencies are in excess of 95%. These factors result in extremely low coating costs.

Preliminary engineering data contained in Bulletin 127 covers ceramic coatings while Bulletin 126 covers the hard-facing alloys. Either or both may be obtained by filling out the coupon below or writing on your company's letterhead. No obligation, of course.

Pump rod sprayed with alumina provides superior protection against abrasion and corrosion.



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	Bore Size	O.D.	Torque	Over-running Speed
Model FS-02	¼"	1¼"	50 in. lbs.	*2400
Model FS-04	⅜" and ½"	1⅝"	200 in. lbs.	*2400

*Higher speeds possible on special applications. Consult with factory.

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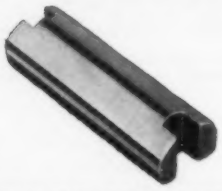
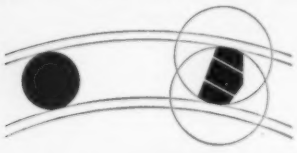
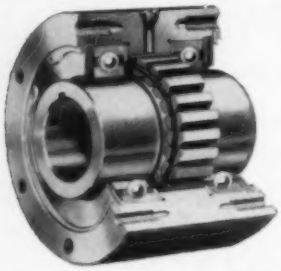


Sprags are an advanced design of precision wedges made of hardened alloy steel. Utilized in a clutch, they increase the efficiency and prolong the life of all equipment using an over-running clutch or ratchet.



The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space—therefore, of increased torque capacity.



Basic construction of the Formsprag Clutch is simple. A full complement of sprags is inserted between inner and outer concentric races. Contact with both race surfaces is maintained by energizing springs.

MORE INFORMATION?

Should you require details on these Formsprag small clutches as well as the complete line, write today for this new 26-page catalog.

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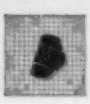

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For your copy of any new catalog or bulletin, circle key numbers in the space indicated. Bulletins are described on pages 273-288.

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4—Belleville Spring Cartridge
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15—Plug-in Potentiometers
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17—Pressure Regulator
18—Switch and Shaft Seals
19—Miniature Thermostat
20—Servo Amplifiers
21—Temperature Pick-Ups
22—Experimental Stainless Springs
23—Enclosed Limit Switch
24—Sub-Miniature Time Delay Relay
25—High Voltage Motor Starters
26—Double-Strand Sprockets
27—Conveyor Belt for Small Pulleys
28—Subminiature Potentiometers
29—Servo Amplifier
30—Motor-Gearhead Clutch
31—Air-Over A-c Motors
32—Polyurethane Foam Rubber
33—Time Delay Relay
34—Direct-Indicating Frequency Meters
35—Speed Governor and Switch
36—Pressure Regulators
37—Miniature Differentials
38—Directional Valve
39—Packless Valves
40—Servo for Amplifier Applications
41—Rubber Gaskets
42—Resistor for Surface Temperature
43—Pressure Transducer
44—Low-Durometer Silicone Rubber
45—Chassis-Mounted Terminals
46—Adjustable Flow Regulator
47—Armored Relay
48—Magnetic Relay
49—Double-Strand Chain Sprocket
50—Low-Range Torque Transducers
51—Remote Position Control
52—PVC Ball Valve

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56—Hydraulic and Pneumatic Switch
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58—Sensing Relay
59—Multiple Instrument Tubing
60—Miniature Thermal Relays
61—Push-Pull Switch
62—Colored Toggle Switch
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66—Tachometer Generator
67—Wiring Lug
68—Miniaturized Setscrews
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71—Remote Bulb Temperature Control
72—Instrument Balls
73—Air Line Filter
74—Core Magnet Meter Movement
75—Servo Component Mounting Plates
76—Magnetic Amplifiers
77—Four-Terminal Voltage Divider
78—Monitor for Frequency, Voltage
79—Blueprint Files Interlock
80—Generator for 1200 Cps
81—Speed-Sensitive Relay
82—M-G Set Converts A-c to D-c
83—Four Templates for Ellipses
84—Drafting-Reference Unit

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87—Plastic Rivets and Grommets, Brochures (2), Fastex.

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89—Nuts, 8 pp., National Machine Products Co.

90—Tinplating, 44 pp., Tin Research Institute Inc.

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128—Precision Switches, 8 pp., Micro-Switch

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131—Central Lubrication Systems, 24 pp., Bijur Lubricating Corp.

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133—Pressure Gages, 4 pp., American Chain & Cable Co., Inc.

134—Remote Positioning Controls, 8 pp., Jordan Co., Inc.

135—Custom-Molded Rubber Parts, 8 pp., Tyer Rubber Co.

136—Packless Valves, 22 pp., Robertshaw-Fulton Controls Co.

137—Steel Data, 256 pp., Joseph T. Ryerson & Son., Inc.

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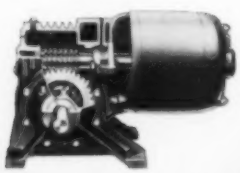

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Point is the manufacturers of this fast, efficient and extremely ingenious dry cleaning storing mechanism told Master what they needed. Light, geared-down, steady power, full start, positive stop. And whenever the attendant in a progressive shop so equipped dials your pants, a Master Gearmotor delivers the goods.

And Master can deliver the goods for *you!* Master components can be integrated in any combination to give you the right horsepower, right shaft speed, right mounting features, in a single, efficient compact unit. See Master for your drives!

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Construction	Open, enclosed, splash-proof, fan-cooled, explosion-proof, special purpose.
Speeds	Single-speed, multi-speed, and variable speed.
Installation	Horizontal and vertical, with or without flanges and other features.
Power Drive Features	Electric brakes (2 types)—5 types of gear reduction up to 432 to 1 ratio. Mechanical and electronic variable speed units—fluid drives—every type of mounting.

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Sunbeam engineers specify long wearing

GRAMIX® iron sprockets

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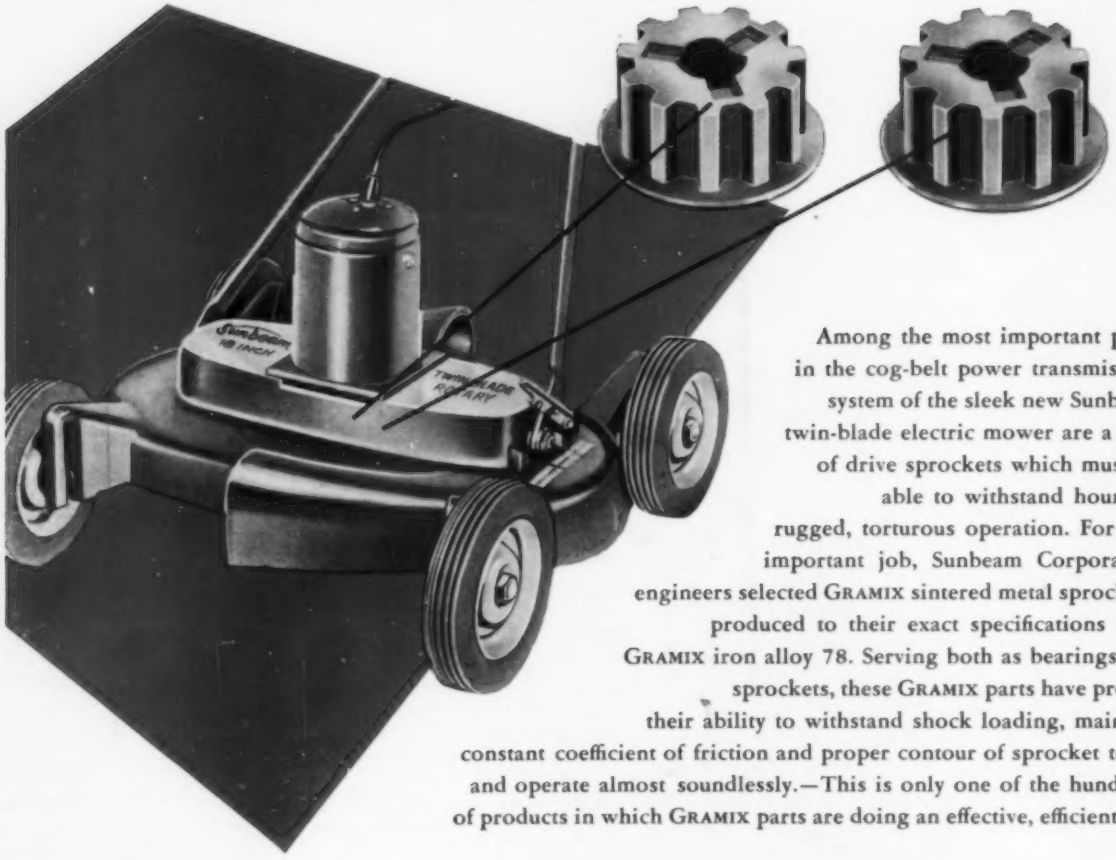

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